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From Professional Development to Pedagogy: Examining How Computer Science Teachers Conceptualize and Apply Culturally Responsive Pedagogy

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The field of computer science continues to lack diverse representation from women and racially minoritized individuals. One way to address the discrepancies in representation is through systematic changes in computer science education from a young age. Pedagogical and instructional changes are needed to promote meaningful and equitable learning that engages students with rigorous and inclusive curricula. We developed an equity-focused professional development program for teachers that promotes culturally responsive pedagogy in the context of computer science education. This study provides an overview of our culturally responsive framework and a qualitative examination of how teachers (n=9) con-

ceptualized and applied culturally responsive pedagogy in their classrooms. Drawing from grounded theory and lesson assessment rubrics, we developed a codebook to analyze teacher interviews, lesson plans, and questionnaire responses. Findings revealed that, following their participation in professional development, teachers were consistently planning to implement a wide range of culturally responsive instructional and pedagogical practices capable of promoting diversity, equity, and inclusion in computer science education.

INTRODUCTION

A major challenge within the discipline of computer science (CS) is recruiting and retaining women and racially minoritized individuals to the field (Casad et al., 2021; Cuny, 2012; Miriti, 2020; National Science Foundation, 2019). The underrepresentation of minoritized groups in computing poses a significant equity issue. Developing CS knowledge and skills can foster a sense of computing competency among CS students, while simultaneously enabling creativity and innovation in the field (Google, 2014; Google & Gallup, 2015). This may lead to further pursuits in computing that enable students to take advantage of the growing high-paid career opportunities in CS-related fields, as well as bring new and important perspectives to CS careers (Perez, 2019; Vakil, 2018).

While there are many explanations for the discrepancies in representation, the most pressing is a result of culturally irrelevant CS education (Scott & White, 2013). As a response, teaching practices can be contoured to engage diverse learners through professional development (PD) that prepares teachers to integrate culturally responsive pedagogy (CRP) into existing school curricula. CRP enables effective teaching, meaningful learning, and equitable learning environments (Gay, 2018; Ladson-Billings, 1995a). As Gay (2018) explains:

> Culturally responsive pedagogy validates, facilitates, liberates, and empowers ethnically diverse students by simultaneously cultivating their cultural integrity, individual abilities, and academic success. It is anchored on four foundational pillars of practice—teacher attitudes and expectations, cultural communication in the classroom, culturally diverse content in the curriculum, and culturally congruent instructional strategies. (p. 53)

Although teachers may be aware of CRP, their perceptions of themselves as culturally responsive educators are often not aligned with their classroom instructional practices (Debnam et al., 2015). One way to address these perceptions is through critical self-reflection. Self-reflection is an essential practice that requires educators to acknowledge their biases and positionality when attempting to integrate CRP into their teaching (Borrero et al., 2018). Only then can teachers authentically represent and harness students' cultural assets within their classrooms (Kohli, 2012).

Our work seeks to address the underrepresentation of minoritized groups in CS by utilizing a culturally responsive framework that integrates knowledge relevant to youth identities and communities with computational learning activities (Codding et al., 2019; Gay, 2018; Ladson-Billings, 1995b; Nieto, 1999). This framework is incorporated into a PD program with an explicit focus on equity built around the construct of technological pedagogical content knowledge (TPACK; Mishra & Koehler, 2006). TPACK builds on Shulman's (1986) pedagogical content knowledge (PCK) to indicate the manner in which technology knowledge (TK) can be integrated with content (CK) and pedagogical knowledge (PK) to support effective use of technology in teaching. In relation to CS, TPACK highlights the need to help teachers build knowledge of foundational CS principles (CK), knowledge of good pedagogical practices (PK) including practices specific to CS instruction (PCK), and knowledge of technology tools relevant to CS instruction (TK) (Vivian & Falkner, 2019). Relatedly, we seek to answer two research questions:

1. How do teachers conceptualize and plan to apply CRP in their classrooms while attending an equity-focused CS PD program?
2. In what ways do teachers apply elements of CRP in their pedagogy and lesson planning following their participation in an equity-focused CS PD?

LITERATURE REVIEW

Elements of Effective PD

PD is widely considered to be a critical force in the implementation of new standards and curricula (Darling-Hammond et al., 2017). To date, there is substantial evidence that effective PD is characterized by seven key elements: focus on content, active learning, collaboration, modeling, expert support, feedback and reflection, and sustained duration (Darling-Hammond

et al., 2017). PD must engage teachers with opportunities to strengthen their *content knowledge* (CK) and pedagogical approaches to instruction. Establishing CK is critical, especially among teachers who have not received sufficient exposure in their preparation programs and need opportunities to deepen their CS knowledge and pedagogical techniques (Century et al., 2013; Margolis et al., 2017). Specifically, it is important to help teachers understand how the big ideas of CS (i.e., computer science principles; College Board, 2017) can be integrated with core curricular content so they can easily apply aspects of the PD into their lessons. PD should cover *active learning* strategies that facilitate teacher engagement. Such strategies include opportunities to observe teaching, analyze student work, design and practice using curricula activities that teachers are expected to implement in their classrooms, and engage in continuous reflection about teaching (Darling-Hammond, Hyler et al., 2017; Darling-Hammond, Wei et al., 2009; Powell et al., 2010).

Further, opportunities for *collaboration* are essential for developing a collective knowledge that transcends individual experiences (Bates & Morgan, 2018). Opportunities for collaboration are particularly important for CS teachers who are often singletons in their school with no colleagues with whom to share experiences (Yadav et al., 2015). Towards this end, *modeling* such as demonstrations or peer observations connected directly to curriculum materials can help teachers set goals and view them as reality within the unique context of their teaching environments (Bates & Morgan, 2018). Similarly, *coaching and expert support* can strengthen teachers' PD experiences by providing individualized feedback that is contextualized to their teaching environments and personalized to their needs (Bates & Morgan, 2018). In fact, *feedback and reflection* are two components that complement each other—constructive feedback allows for reflection and leads to change in practice (Bates & Morgan, 2018; Darling-Hammond, 2017). Finally, effective PD is of *sustained duration* expanding over multiple days accumulating at least 20 hours or more and provides follow-up support (Desimone & Garet, 2015). Follow-up support is important in the field of CS as a means for overcoming teacher isolation and for providing job-embedded assistance in a field that constantly advances (Margolis et al., 2017). Incorporating these seven elements encourages transformative teaching that lasts from the PD into the classroom (Darling-Hammond, 2017).

While the above elements are widely recognized as essential in supporting teacher learning, there is scarce research on how to apply them in designing effective PD for CS teachers (Menekse, 2015). Although CS curricula and accompanying PD have been heavily promoted in recent years through initiatives such as *CS for All*, relatively little is known about how

teachers can support CS education in formal school settings (Goode, Skorodinsky et al., 2020). Specifically, an extended literature review conducted by Menekse (2015) uncovered just 21 studies related to PD in CS. Importantly, Menekse's review found that the majority of the CS PD efforts were not consistent with principles of high-quality PD reported in the literature (see Darling-Hammond et al., 2017). CS PD typically lasted one week or less, neglected to provide follow-up support, failed to include active learning strategies (e.g., observations, reflection, etc.) and did not explicitly address pedagogy for teaching CS.

Although a number of new PD efforts and associated studies have emerged since Menekse's (2015) review, the majority of them focus on popular high school CS curricula, such as Computer Science Principles (Gray et al., 2016) or Beauty and Joy of Computing (Milliken et al., 2019). Such programs are intended primarily for teachers teaching stand-alone CS curricula and do not involve teachers at the elementary or middle school levels interested in integrating principles of computing into content-area curricula. Other PD programs were launched by prominent organizations that provide K-12 curriculum to schools, such as Code.org, BootUp, Project Lead the Way, and Google (DeLyser et al., 2018; Rich et al., 2021). Although these programs include teachers across K-12, they also focus on the implementation of specific, stand-alone curricula developed by the aforementioned organizations. While these programs have been beneficial in supporting both novice and experienced teachers, in some cases (e.g., Project Lead the Way) they require extensive financial resources which further accentuate equity considerations for school systems serving high percentages of minoritized students (Franklin et al., 2020). As a result, more work is still needed in the design, implementation, and research of high-quality PD programs that help teachers implement rigorous and inclusive CS instruction aligned with core content area curricula at no cost (Goode, Skorodinsky, et al., 2020). In this work, we present one effort that supports teachers toward this goal.

Equity-Focused Professional Development in Computing

According to recent data, only 16% of teachers view themselves as being well-prepared to incorporate students' cultural backgrounds into CS instruction (Gordon & Heck, 2019). Yet, equity is not typically at the center of PD programs focusing on CS (Goode, Ivey et al., 2020). In order to promote equity in CS education, it is necessary to help teachers understand their own positionality as CS teachers, address their own biases pertaining to who can

be successful in computing, and develop the knowledge and skills necessary for incorporating equitable practices rooted in CRP (Goode, Ivey et al., 2020). As a result, CS PD programs should expand beyond just CS content (CK) and pedagogical knowledge (PK & PCK) to also incorporate issues of equity that help address the long-standing underrepresentation of female and racially minoritized students in computing.

One of the most widely researched CS PD programs with an explicit focus on equity is associated with the Exploring Computer Science (ECS) curriculum. The ECS curriculum was first launched in the Los Angeles Unified School District and was designed with the overall intent of broadening participation in computing for females and students of color (Margolis et al., 2014). The ECS curriculum integrates CS content with computational practices to introduce students to computing ideas rather than specific programming languages (Goode et al., 2012). The ECS PD format provides an intensive learning experience for teachers over a 2-year period and helps them develop the content and pedagogical knowledge needed to engage students in learning the ECS materials. Further, in-classroom coaching for collaboration and reflection supports teacher efforts for inquiry and equity-based teaching practices (Margolis et al., 2017). Importantly, the ECS program encourages teachers to develop habits of reflection to examine their pedagogy and the ways it influences student learning, particularly for underrepresented populations (Goode et al., 2012).

In more recent work, Goode, Ivey et al., (2020), examined how teachers engage in learning about race and equity in the context of a week-long summer PD program associated with the ECS curriculum. During the week, teachers were exposed to CS concepts, inquiry-oriented practices, and curricular lessons focusing on race and cultural knowledge in CS. Data were collected from 94 teacher participants in the form of field notes capturing how teachers talked to each other about race and surveys focusing on teacher beliefs about equity, race, and CS over the course of their participation in PD. Findings indicated that teachers developed a sense of urgency to broaden participation in computing as well a sense of agency to disrupt inequities in CS among underrepresented populations. Further, they developed beliefs and instructional skills that support equity teaching in CS. More studies like this are needed to help teachers learn about equitable pedagogical practices that utilize students' cultural backgrounds in order to broaden participation in computing. In this work, we present a PD approach that helps teachers move towards this goal, by examining their own beliefs and using elements of CRP to help embrace their responsibility in disrupting inequities in CS.

CONTEXT OF THIS WORK

This work is situated in a larger effort to improve the teaching of computing in the U.S. through a three-pronged approach: teacher PD, a college field experience course, and sustainable school partnerships (Pollock et al., 2015). In this work, we focus explicitly on our approach to teacher PD, which was designed and delivered by the authors. Consistent with characteristics of effective PD, our program incorporates a two-tiered approach to supporting teachers as they learn to integrate CS principles across K-12 curricula: an annual week-long Summer Institute and follow-up support through undergraduates enrolled in the college field experience course. Our week-long Summer Institute focuses on preparing teachers in grades 5-12 to integrate CS principles into existing STEM modules. It includes explicit attention to CS content (CK), CS resources and tools (TK), and strategies for broadening participation in computing (Pollock et al., 2015; see Table 1 for an overview of the PD schedule).

In this work, CK refers to big ideas of CS, including creativity, abstraction, data, algorithms, programming, Internet, and impacts of computing (College Board, 2017). TK refers to CS-related technologies such as programming software and robotics. Knowledge of pedagogy refers to knowledge of general pedagogical strategies (PK), such as inquiry and collaboration, as well as knowledge specific to the teaching of CS (PCK), including: (a) pair-programming—a technique where two programmers work together at the same station; (b) CS Unplugged—kinesthetic activities that teach CS concepts without computers (Bell et al., 2008); and (c) process oriented guided inquiry learning (POGIL)—activities that engage students in active construction of CS learning while working in small teams (see https://pogil.org). Specifically, teachers acquire pedagogical knowledge for teaching CS by participating in pair-programming, open-ended projects allowing for creativity, a variety of CS Unplugged activities, collaborative projects, assessment of computational artifacts, and sustained reflection (*active learning & reflection*). Additionally, participants engage in activities that help them draw connections between key ideas in computing and core curricular standards by working in teams to design CS-integrated lessons (*collaboration*). PD instructors model effective teaching strategies (*modeling*) and teachers receive feedback on their lesson drafts from PD instructors and other participants (*feedback*). Finally, a series of sessions focus on the impacts of CS on society and promising practices for recruiting and retaining diverse students in CS.

Table 1
Overview of Summer Institute PD Schedule (2019)

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9:00-10:15	Introductions, Program Purpose & CS Unplugged – *Icebreaker*	Explore Algorithm Lesson Plans & CS Unplugged – *Algorithms*	Assessing Scratch Products for Creativity, Rubrics & Dr. Scratch	Creating a VR scene using A-Frame	Finalize Lesson Plans & CS Unplugged – *Abstraction*
10:15-10:30	*Break*				
10:30-11:45	Programming with Ozobots using Two Languages (*Color Lines & Block-Based*)	Continuation of Algorithms Lesson & **Culturally Responsive**	Data Abstraction with CORGIS Visualizer	Creativity with Micro:bits	Lesson Sharing & **Broadening Participation**
11:45-12:30	*Lunch*				*Adjourn*
12:30-1:00	**Broadening Participation in Computing**	CS First Lesson Exploration with Google Representative	CS Unplugged – *Live Guess Who Game* & Explore Lessons on Querying	CS Unplugged – *Internet* & Cybersecurity	
1:00-2:15	Continuation of *Ozobots* – Introduce Creativity and Brainstorm Lessons		Digital Art in Pixels	CS Tools: Exploring Computational Curriculum Kits	
2:15-2:30	*Break*				
2:30-3:45	From Standards to Lessons & **Culturally Responsive**	Continuation of CS First Lesson Exploration with Google Representative	**Culturally Responsive Lesson Planning**, Lesson Development & Peer Feedback	**Culturally Responsive Lesson Planning**, Lesson Development & Peer Feedback	
3:45-4:00	Reflection on Learning				
4:00-4:30	*Adjourn & Individual Consultations*				

While our Summer Institute provides opportunities for the development of CS knowledge and pedagogy, teachers need ongoing support throughout the academic year (*sustained duration*). To accomplish this goal, we established a field experience college service-learning course that is open to undergraduates with at least one prior course in CS (see Pollock et al., 2015). The course combines college classroom meetings with field experience in K-12 schools. During the course, undergraduates and faculty in CS

and education work together to: (a) identify computing lessons and activities relevant to students' age groups, interests, and prior experiences; (b) model pedagogical strategies for teaching CS that have shown promise in broadening participation in computing; (c) prepare and analyze computing lesson plans; and (d) reflect on successes and challenges during the field experience (Codding et al., 2020; Mouza et al., 2016; Yang et al., 2021). In the field, undergraduates meet with teachers to discuss lesson plans, solicit input, and work out logistics (*coaching & expert support*). They also co-facilitate classroom activities or after-school programs with their partner teacher (Codding et al., 2020; Mouza et al., 2016; Yang et al., 2021).

Culturally Responsive & Equity-Focused PD Model

Our PD program has expanded to include a culturally responsive and equity-focused pedagogical framework aimed at engaging teachers and undergraduate student facilitators in *self-reflection* and culturally responsive teaching strategies (Codding et al., 2020; Codding et al., 2019). We began to pilot our culturally responsive PD model during the 2018 Summer Institute. This first iteration focused on highlighting the underrepresentation of racially minoritized and female students in CS and preparing teachers with techniques for attracting, maintaining, and engaging students from underrepresented groups. Teachers participated in two PD sessions aimed at broadening participation in computing, during which facilitators dispelled myths about underrepresented groups in CS (e.g., girls are not interested in computing) and addressed the impact of personal biases and microaggressions in CS (Gershenson et al., 2016). These sessions engaged teachers in self-reflection to understand their positionality and examine their own biases, specifically biases pertaining to perceived intellectual abilities based on race, gender, and socioeconomic status (Howard, 2003). Teachers also participated in four PD sessions focused on integrating CRP into their lesson planning, during which PD facilitators introduced CRP and provided specific examples of CRP in CS (Gay, 2018; Ladson-Billings, 1995b; Nieto, 1999; Scott et al., 2010). These sessions focused on preparing teachers to integrate knowledge relevant to youth identities and communities with computational learning activities.

Following the 2018 Summer Institute, we conducted a series of semi-structured interviews to examine the effectiveness of this framework (Codding et al., 2019). Findings suggested that facilitators were able to successfully communicate the need for equity and culturally responsiveness in CS education. The PD sessions also motivated teachers to incorporate CRP and

equity-focused practices in their lessons. However, teachers left the PD with an inconsistent understanding of CRP and many teachers reported feeling unsure of how to implement CRP in their own classrooms. As one teacher explained, CRP prioritizes "recognizing my own biases that I would have internally, which I'm not aware of, so I'm not sure how I'm going to do that" (Codding et al., 2019). Our initial approach to CRP PD lacked the specificity teachers needed to successfully confront personal biases, implement pedagogical changes, and adapt their CS curriculum. The PD emphasized urgency without adequately developing teachers' agency to implement CRP successfully into their CS classrooms. In response to these findings, we adapted our PD model to integrate our culturally responsive and equity-focused framework into every aspect of our program (Figure 1), including all three elements of the Summer Institute and the contextualized support provided by our undergraduate student facilitators throughout the school year.

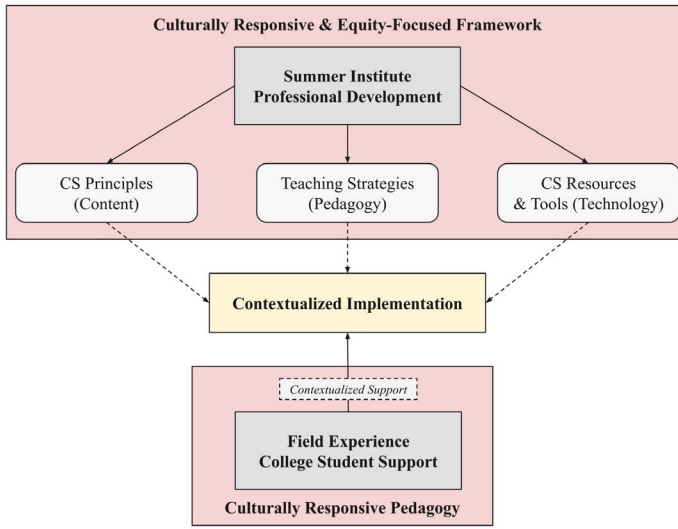

Figure 1. Culturally Responsive and Equity-Focused PD Model (Codding et al., 2020).

Our revised PD model seeks to better prepare teachers to successfully implement CRP in their CS classrooms. In addition to engaging teachers in self-reflection and promoting specific CRP teaching strategies, the revised

model provides teachers with culturally responsive resources and contextualized approaches for integrating CS principles. To incorporate CRP into CS principles, we emphasized creativity as a central principle for creating culturally responsive curriculum and assessments. Beginning in the fall of 2018, we also integrated our CRP and equity-focused framework into the curriculum for undergraduate student facilitators in the field experience course. These sessions prepared undergraduate facilitators for culturally responsive teaching by engaging them in guided self-reflection and equipping them with culturally responsive teaching strategies. Expanding our framework to include undergraduate facilitators provided teachers with contextualized and individually tailored support as they sought to integrate CRP into their own CS classrooms.

During the 2019 Summer Institute, we focused on four specific CRP elements: promoting diversity, self-reflection, centering equity, and implementation (Table 2). Sessions promoting these elements appear on our schedule under two designations: *broadening participation in computing* and *culturally responsive* (see Table 1). Each session lasted approximately 30 minutes. To promote *diversity*, teachers learned research-based strategies for increasing participation in CS and making their curriculum relevant through addressing real-world problems. Teachers engaged in self-reflection to confront biases, practice addressing microaggressions, and apply a cultural lens. To center *equity*, teachers engaged in sample culturally responsive activities and learned to center creativity in their lesson design. To promote implementation, teachers worked collaboratively to develop conceptual lesson plans that intentionally integrate culturally responsive practices. These four CRP elements were chosen to deepen teachers' understanding of CRP and prepare them to successfully incorporate CRP and equity-focused practices in their classrooms.

During the PD, we addressed each of these CRP elements through a series of activities adapted and implemented by the lead author. Table 3 provides detailed descriptions of six key activities from our 2019 Summer Institute. Each activity was selected to promote engagement with the CRP elements and adapted to meet the needs of our participating teachers. This study focuses on how teachers processed and applied CRP and equity during the 2019 Summer Institute and subsequently in their classrooms during the 2019-2020 school year.

Table 2
Culturally Responsive and Equity-Focused PD Elements

Element	Purpose/Explanation	PD Activities	Literature
Promoting Diversity	Increasing participation in CS through equity-focused and research-based approaches Making CS relevant to solving real-world problems	"Identify, Recognize, Invite, Invite Together"	Alvarado et al., 2012
Self-Reflection	Defining CRP and reflecting on the impact of culture Thinking about ourselves and our students through a cultural lens Dispelling myths and confronting internal biases Identifying and avoiding microaggressions	Partner Walk Five Minute Poems Identity Wheel Identifying & Dispelling Myths Addressing Microaggression	Gay, 2018; Gershenson et al., 2016; Ladson-Billings, 1995b; Nieto, 1999; Tatum, 2007
Centering Equity	Adapting pedagogical approaches Centering culturally responsive interactions	Examples of CRP in CS Designing Robots to Save the World Exploring Shared Interests Assessing Creativity	Pollock, 2008; Scott et al., 2010
Implementation	Integrating CRP concepts into CS lesson plans Adapting existing curriculum to be culturally responsive	Peer feedback and support; individual and contextualized support	

METHODS

Participants

For this study, we focus on teachers who participated in our program during the 2019 Summer Institute. A total of 25 teachers attended the 2019 Summer Institute. We used criterion sampling to recruit teachers who worked in schools that serve a racially and socioeconomically diverse population (n=9). All nine of the selected teachers created conceptual lesson plans (i.e., lesson plan teachers planned to apply in their classrooms) and participated in individual interviews on the last day of the 2019 Summer Institute. Of these, six teachers completed an online questionnaire and provided an applied lesson plan (i.e., lesson plan teachers implemented in their classroom) following their participation in the Summer Institute. Further, four of the nine participating teachers previously attended our 2018 Sum-

mer Institute and participated in the pilot version of our culturally responsive and equity-focused PD model. In addition to core elementary teachers, participants taught business, technology, and library classes at either the elementary or middle school level. Several participants also taught after school CS programs. Table 4 provides an overview of the participants and associated data.

Table 3
Description of CRP-Related PD Activities

PD Activity	Description
Identify, Recognize, Invite, Invite Together	After helping teachers dispel common myths about why there are fewer female and BIPOC students in CS classes, they learned a four-step approach for improving the recruitment and retention of these minoritized students based on the successful recruitment and retention of female students in CS at Harvey Mudd College (Alvarado et al., 2012). Teachers learn to identify promising students, recognize them for their abilities and achievements, invite them to take a CS class (or a more advanced CS class), and invite groups of students to sign up for CS classes together.
Partner Walk	Teachers engaged in self-reflection by telling personal stories. Pairs of teachers take a walk during which they take turns talking for three minutes straight about unique traditions from their family or culture. This activity was developed by Liz Brown at the University of Canterbury, who based this work in the Māori tradition of whānau or *extended family*.
Five Minute Poems	This activity was developed by Beverly Tatum (2007) to engage teachers in a written reflection on the community and culture that contextualized their childhood. The poem consists of four stanzas that each begin with the phrase "I am from." The first stanza contains the familiar sights, sounds, or smells from their neighborhood. The second stanza describes familiar foods they grew up eating. The third stanza shares family sayings and the fourth stanza describes specific people who influenced their life.
Social Identity Wheel	Teachers reflect on some of their social identities (race, gender, sex, (dis) ability, sexual orientation, etc.) and reflect on how these identities impact their self-perception or how they are perceived by others. For this activity, teachers complete the social identity wheel worksheet adapted for use by the Program on Intergroup Relations and the Spectrum Center, University of Michigan.
Addressing Microaggressions	Teachers were given examples of microaggressions female and BIPOC students may face in CS classrooms. Teachers worked in groups to practice identifying and addressing each scenario. This activity was adapted from the Computer Science Teaching Tips website (csteachingtips.org).
Designing Robots to Save the World	This activity asks teams of teachers to design a robot that would make the world a better place. The development of this world-changing robot relies on a combination of creativity, problem solving, and technological design as they work together to address real-world problems. This activity was originally designed by our team for middle school students in an after-school coding program.

Table 4
Participant Demographics

Pseudonym	Race	Gender	Experience	Grade Level
Beth[+]	White	F	9 years	Elementary
Cindy [*+]	Asian	F	12 years	Elementary
Deborah [*+]	Black	F	7 years	Middle School
Emma[+]	White	F	6 years	Elementary
Kathy [*+]	White	F	23 years	Middle School
Lane	White	F	26 years	Elementary
Mary [*+]	White	F	22 years	Middle School
Sandy	White	F	8 years	Elementary
Tara	Black	F	11 years	Elementary

Notes. All participants completed individual interviews on the last day of the 2019 Summer Institute.
[*] Participated in 2018 Summer Institute
[+] Completed 2020 Online Questionnaire and Submitted 2019-2020 Applied Lesson Plans

Data Collection

Qualitative data were collected from four sources: individual interviews and conceptual lesson plans collected during the 2019 Summer Institute, as well as an online questionnaire and applied lesson plans collected following the 2019-2020 school year (Figure 2).

Interviews

On the final day of the 2019 Summer Institute, we conducted semi-structured individual interviews with participating teachers (n=9). Teachers were asked nine questions that targeted their experiences during the PD, the effectiveness of the culturally responsive sessions, and potential needs for follow-up support. Four questions were specific to the CRP elements of our PD, which asked teachers to: (1) define CRP, (2) identify connections between CRP and CS, (3) provide an example of how students can use technology to solve real-world problems in their community, and (4) explain how they plan to apply what they learned about CRP following the PD. The four teachers who attended the previous year's PD offerings (see Table 3) answered three additional questions: (1) their reason for attending multiple years, (2) applications of CRP in their classroom following the pre-

vious year's PD, and (3) the perceived impact of the second year of PD on their knowledge of CRP. Interview data were de-identified prior to analysis to avoid analysis bias.

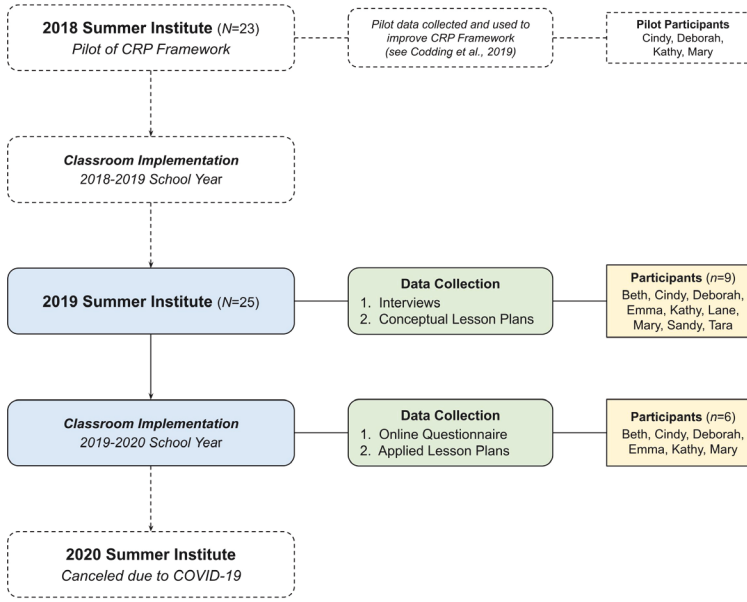

Figure 2. Research Procedures and PD Timeline.

Conceptual Lesson Plans

Participating teachers worked independently and in small groups of two to five throughout the week-long Summer Institute to design a conceptual lesson plan—a CS lesson plan that could be used in their own classrooms. On the final day of the PD, we collected conceptual lesson plans from all 25 participants—four lesson plans written by individual teachers and five lesson plans written by small groups (n=9). In addition to providing a detailed lesson plan, teachers were asked to indicate the target audience (e.g., grade level and subject area), lesson goals, CS standards (CK), required technologies (TK), and learning assessment (PK). Teachers were also asked to identify how they sought to apply CRP in their lesson plan (PCK & TPACK). Teachers designed lesson plans that could be used for multiple content areas in addition to CS classes, including language arts, math, business, and li-

brary. Lesson plans covered a wide range of CS topics ranging from block-coding robots to developing fairy tale storyboards in Scratch and coding websites using HTML. Electronic copies of each lesson plan and accompanying materials were collected via Google Drive. Additionally, teachers created physical posters depicting key elements of their lesson plans, which were presented during a gallery walk on the final day (Figure 3). We refer to these lesson plans as "conceptual" because they provide data concerning how teachers *planned* to implement CRP into their teaching.

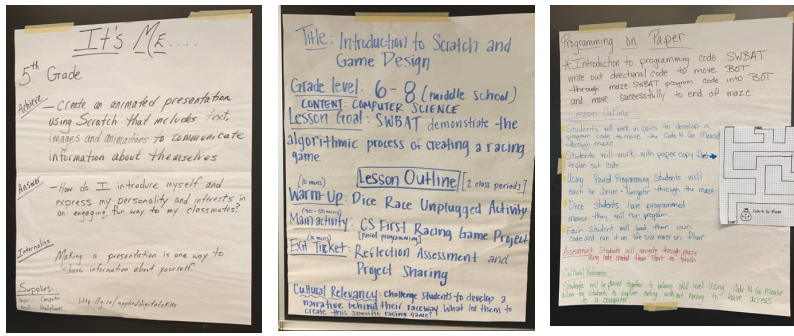

Figure 3. Sample Lesson Plan Posters (2019).

Questionnaire & Applied Lesson Plans

In spring 2020, due to COVID-19 restrictions, we administered an online questionnaire via Qualtrics (instead of interviews) that consisted of seven questions, which asked teachers to self-report their use of CRP elements during the 2019-2020 school year. Teachers were asked to (1) describe what they think it means to be a culturally responsive CS teacher; (2) give two examples of how they have implemented CRP; (3) identify what support they need to maximize their success in implementing CRP; and (4) self-report how often they incorporated four specific element of CRP in their CS classroom: pair-programming, creativity, student-led activities, and real-world problem solving. Following the questionnaire, teachers were asked to submit one culturally responsive lesson plan they had taught during the 2019-2020 school year. Applied lesson plans (n=6) varied in format and content, depending on the teacher. Beth and Cindy worked as co-teachers during the 2019-2020 school year, but they each submitted separate lesson plans for analysis. We refer to these lesson plans as "applied" because they provide data about how teachers *applied* CRP in their classrooms after attending the PD.

Data Analysis

Interview (de-identified) and questionnaire data were analyzed to identify common and unique themes using an analytical approach inspired by grounded theory (Glaser & Strauss, 1967). Themes were categorized for analysis based on our first research question, which examines how teachers are conceptualizing CRP and equity in the context of CS. Code categories were developed based on four emergent themes: (a) cultural awareness, (b) student-centered pedagogies, (c) inclusion and belonging, and (d) equal access. Codes were refined and applied during two rounds of coding (Table 5).

Table 5

Evolution of Themes and Code Refinement

Guiding Research Question			
How do teachers conceptualize and plan to apply CRP in their classrooms while attending an equity-focused CS PD program?			
First Iteration			
Emergent Themes			
1. Cultural Differences	2. Student Needs	3A. Inclusion – Membership 3B. Inclusion–Identity	4. Exclusion?
Theme Descriptions			
1. Teachers recognize that students have various and unique cultural needs that need to be accommodated in their classroom environment.	2. Teachers recognize that students have different learning needs and backgrounds / interests.	3A. Teachers mention CRP as a way off uniting and bring together a group of students in CS. 3B. Teachers mention CRP as a way for students to come into their identities/joint identity.	4. Teachers mention CRP as something they are lacking in their CS programs. It is a way for them to explain a sense of exclusion in their programs.
Second Iteration			
Themes			
1. Cultural Awareness	2. Centering Students	3. Inclusion	4. Equal Access
Codes			
1A. Centering Cultural Differences 1B. Adapting Classroom Culture 1C. Introspection & Reflection	2A. Student Needs 2B. Student-Centered Pedagogy	3A. Membership 3B. Identity	4A. Removing Barriers 4B. Increased Programming

Lesson plans were analyzed to examine how teachers applied CRP to their pedagogical and curricular design. For this analysis, we developed a

codebook, drawing from three lesson assessment rubrics (Aguilar-Valdez, 2015; Utah Valley University, n.d.; Weintrop et al., 2019). Codes were grouped into two code categories (equity & inclusion and content & pedagogy) and refined during two rounds of coding by the researchers. Lesson plans were analyzed in a third round of coding using our final codebook (Table 6).

Table 6
Codebook for Lesson Plan Analysis

Equity & Inclusion	
Code	*Criteria*
Culture	Incorporates the diverse cultures, perspectives, languages, and community values of students (cultural heritage and contemporary youth culture) Gives students the opportunity to share their own culture and cultural heritage Lesson incorporates real-world connections Connects learning to students' homes, neighborhoods, and communities
Authentic Identity	Connects to students' interests without relying on stereotypes Opportunities for students to contribute their knowledge, perspectives, and experiences related to lesson topic Student identities represented in the curriculum and classroom materials Opportunities for students to represent themselves in their projects
CS Identity	Creating a space that encourages a sense computer scientist identity
Exceptionalities	Adapted for a variety of different types of learners (*e.g., ELL, Special Ed*) using alternatives, such as translations, pictures, and graphic organizers Extensions activities for students who meet the performance expectations Assessment methods are accessible and do not penalize for exceptionalities
Social Justice	Connect learning to social, political, or environmental issues
Content & Pedagogy	
CS Content	Coverage of the non-CS topics used as framing (*e.g., historical events*) Aligns with standards (*e.g., K-12 CSTA Computer Science Standards*) Content follows trajectory from less to more complex Integrates disciplinary terminology and promotes student usage Content tailored to student prior knowledge and skills within CS
Pedagogical Practices	Students engage in computing skills and computational thinking Collaboration or peer-feedback Engaging and varied instructional approaches and learning strategies (*e.g., discussions and student-centered approaches*) Opportunities to share completed work with classmates and/or community
Instructional Design	Incorporates prior knowledge unrelated to CS content (*e.g., cooking, music*) Questions promote higher order thinking (*apply, analyze, evaluate*) Scaffolding to promote understanding and independence (*Use-Modify-Create*) Opportunities to explore and provide solutions to open-ended questions Provides opportunities for students to reflect and express their learning
Assessment	Objective-based assessments present throughout instruction Clear assessment criteria shared with students Students involved in self-assessment

RESULTS

Findings revealed that, following participation in the culturally responsive and equity-focused Summer Institute, all participating teachers were able to understand and apply CRP to support CS instruction within the context of their individual communities and classrooms.

Conceptual Understanding

Participating in the Summer Institute helped teachers form a clear conceptual understanding of CRP and take steps toward implementing CRP in the context of CS education.

Conceptualizing & Contextualizing CRP

The revisions to our culturally responsive framework and PD model helped teachers develop a more robust understanding of CRP. Findings from our pilot study revealed that teachers initially developed a shallow and inconsistent understanding of CRP following our 2018 Summer Institute (Codding et al., 2019). In contrast, following their participation in our 2019 Summer Institute, teachers were able to articulate their understanding of CRP through the themes of cultural awareness, student-centered pedagogies, inclusion and belonging, and equal access.

Cultural Awareness. In discussing the importance of cultural awareness, teachers identified three underlying elements: centering cultural differences, adapting classroom culture, and engaging in thoughtful self-reflection. First, teachers demonstrated a willingness to center students' cultural needs and differences in designing their learning environment. For example, Deborah emphasized the importance of "breaking through barriers" in order to encourage students to open up and fully engage in the classroom community. Similarly, Emma explained that being culturally responsive means "making sure that your teaching practices and your classroom environment" meet the "cultural needs of your students." Several teachers also noted that knowing your students and accommodating cultural needs can improve student experiences in CS. As Sandy explained, "Knowing your student is what makes everything better . . . when it comes to teaching" and improving student experiences in CS. She further explained, "Understanding our students, knowing where they come from, knowing their interests and then kind of building off that is what culturally responsive teaching practices are."

Second, teachers recognized the need to adapt classroom culture in order to be more responsive to their students. As Sandy explained, students

often experience challenges during the school day and although "that might not be the [right] time" to discuss it in class, it is important for students to know that they can come to the teacher for support. For Sandy, creating space to adapt to student needs is an important aspect of being culturally responsive. Fostering an adaptive and responsive classroom culture facilitates an inclusive classroom environment, which is a foundational part of CRP. Similarly, Tara planned to create an inclusive classroom culture by continuing the use of differentiated instruction to support students in reaching a collective goal: "Even if you're not doing the same thing, you're heading towards the same goal because of your abilities." Further, Tara focused on strengthening inclusion by highlighting student similarities, because she believes that CS should "include everyone regardless of their differences or similarities." For Deborah, student differences offered a way to celebrate diversity, rather than fueling isolation. She organized student groups using pictures of diverse CEOs, specifically highlighting women of color to reflect the identities of her student population. For these teachers, responsive classroom culture centered around collectively celebrating differences.

Third, teachers noted the importance of thoughtful self-reflection in their development as culturally responsive educators. Addressing authentic equity issues, especially issues contextualized in educational settings, helped teachers recognize the importance of acknowledging different points of privilege and taking a step back to say, "Oh, wait a minute. This isn't the starting point for most of our students" (Cindy). For Beth, thoughtful self-reflection meant that after "pushing past those barriers and biases," she would be in a position to truly grant "access to everybody." Through self-reflection and increased cultural awareness, teachers were able to theorize how they could apply a cultural lens in their own classrooms.

Student-Centered Learning. Teachers also thought about CRP as a way to center student needs, cultural identities, and student-centered pedagogy within their learning environment. At the end of the Summer Institute, Cindy emphasized that CS education is not about "students just fitting in one mold," because such an approach would mean "completely neglecting an entire population of people because we're not looking at their needs." Teachers also recognized that CRP includes acknowledging and valuing students' unique learning needs, backgrounds, and interests. For example, teachers mentioned adopting a student-centered pedagogy to meet their students' needs by adapting their teaching style or learning environment. As Cindy explained, "Kids need to touch and build and make. This is the way teaching should be." Through student-centered pedagogies, teachers were able to reimagine their classrooms as culturally responsive spaces that could

meet the needs of their own unique students. Similarly, Kathy understood student-centered learning as not only addressing students' needs but also helping students independently recognize their own needs and interests as part of their identities. As she explained, "Students really do love computers and if we encourage those students to be more involved with computer science, maybe we're going to bring out a strength that we didn't know that they had."

Inclusion & Belonging. Teachers thought about creating a sense of inclusion and belonging in their CS classrooms through emphasizing membership and student identity. For example, teachers described CRP as a way to bring students together as a community. Cindy described culturally responsive CS as a meaningful way to "pull in kids that don't feel like they are contributing members of our community," especially students who feel like they are "not good here." Rather than labeling students based on language abilities or behavior needs, "computer science is a way to unify everybody and say hey, we're all learning something new. Nobody knows how to do this" (Cindy). Similarly, Kathy described CRP as a way to "make sure all students feel like they could be successful in computer science," which she sought to include by highlighting successful women and people of color in her classroom. For Kathy, CRP comes down to making sure her students know that, despite widespread stereotypes, "everybody can be successful in computer science."

Equal Access. Teachers identified the need to make culturally responsive pedagogical changes that would prioritize equal access. For example, several teachers suggested utilizing CS Unplugged activities to promote CS exposure even when access to technology was limited. Teachers also noted that students may have a lack of resources inside and outside of the school to implement CS activities using computers. Following the PD, teachers recognized the importance of making CS accessible and inclusive for all students. According to Tara, the essence of CRP in CS is that everyone "should have access to what we're doing, somehow at some level." Several teachers discussed ideas for recruiting and retaining racially minoritized and female students to give them access and exposure to CS through afterschool computing clubs. Teachers thought about CRP as a model for creating equal access that would help diversify CS. As Beth explained:

> I believe in order to be a culturally responsive computer science teacher you must be able to teach in order to meet all of your students' learning needs in a cross-curricular or multicultural setting. We created a computer science club at school where teachers encouraged students of all genders and ethnicities to join. Being a culturally responsive

> computer science teacher is making it important that all students in our schools have access to computer science opportunities.

Beth prioritized equal access for all her students as a central feature of integrating CRP into her work as a CS teacher.

Integrating CRP into Conceptual Lesson Plans

Teachers' conceptual lesson plans, which were developed during the Summer Institute, provide insight into how they planned to integrate elements of CRP into their content and pedagogical approaches. Findings are divided into two categories: (1) equity and inclusion, which examines how teachers planned to address issues of culture, identity, exceptionalities, and social justice within their lesson; and (2) content and pedagogy, which examines how teachers planned to adapt their content and pedagogical approaches to be culturally responsive. Table 7 provides an overview of these findings in comparison to data from the applied lesson plans.

Table 7

Code Distribution in Conceptual and Applied Lesson Plans

Code	Lesson Plan Applications			
	Conceptual (*n*=9)		Applied (*n*=6)	
	n	%	*n*	%
Equity & Inclusion				
Culture	3	33.33%	5	83.33%
Authentic Identity	7	77.78%	3	50.00%
CS Identity	1	11.11%	3	50.00%
Exceptionalities	6	66.67%	3	50.00%
Social Justice	0	0.00%	1	16.67%
Content & Pedagogy				
CS Content	9	100.00%	6	100.00%
Pedagogical Practices	9	100.00%	6	100.00%
Instructional Design	7	77.78%	5	83.33%
Assessment	5	55.56%	5	83.33%

Equity & Inclusion. Teachers successfully incorporated elements of equity and inclusion into their conceptual lesson plans. Three conceptual lesson plans incorporated connections to diverse cultures (including lessons by Deborah and Sandy). For example, one lesson plan featured an activity

during which students explored and adapted fairy tales from different cultures to reflect their own identities. Seven conceptual lesson plans incorporated expressions of authentic identity within CS activities (including lessons by Beth, Cindy, Deborah, Emma, Lane, and Sandy). For example, Deborah planned to have her students develop a program based on an adaptation of the Five Minute Poem activity (see Table 3; Tatem, 2007), which she hoped would help her learn about her students' authentic identities. One conceptual lesson plan (Deborah) promoted CS identity to increase students' sense of belonging in the field of CS. For example, students cultivated their digital identities and teachers designed activities to promote digital citizenship. Six conceptual lesson plans indicated adaptations for accommodating student exceptionalities (including lessons by Beth, Cindy, Emma, Lane, and Sandy). For example, teachers planned to provide material in different languages for English language learners to ensure learning is accessible for all students. Data, however, indicate that teachers did not plan to address issues of social justice with students in their conceptual lesson plans.

In one conceptual lesson plan, a group of five upper elementary teachers (including Sandy) proposed a lesson on fairy tales that integrated CS into their ELA curriculum. This lesson satisfied three of the equity and inclusion subcategories: culture, authentic identities, and exceptionalities. The lesson began with students watching a video that detailed the story of *Little Red Riding Hood*. To accommodate for exceptionalities, teachers also provided students with a transcript of the video. After viewing the video, students were encouraged to use a variety of resources (e.g., libraries, family members, and search engines) to research a new fairy tale that they could then rewrite to reflect their own heritage or identity. The lesson plan included a graphic organizer to help students compare elements of the original fairy tale with their own traditions. Finally, students were asked to create an augmented reality fairy tale on CoSpaces and share their creations during a gallery walk activity. Teachers also included a detailed rubric that provided students with a clear indication of expectations. This conceptual lesson plan incorporates the diversity of students without relying on stereotypes. It also provides students the opportunity to represent themselves creatively in their projects. These teachers considered the various learning exceptionalities their future students may have and listed alternative accommodations to overcome barriers and ensure equal access. Finally, assessment expectations were accessible to all students and did not penalize for exceptionalities. The activities in this lesson were created for a classroom environment with access to technology and the Internet.

Content & Pedagogy. Teachers were able to successfully incorporate CRP into the content and pedagogy of their conceptual lesson plans.

All nine conceptual lesson plans incorporated CRP into their CS content to promote student engagement. For example, teachers designed lesson plans around CS standards (CK) and tailored content to students' anticipated knowledge and skills (PK & PCK). All nine conceptual lesson plans indicated culturally responsive pedagogical practices. To this end, teachers planned to use strategies such as pair-programming to promote collaboration, while also accommodating exceptionalities. Seven conceptual lesson plans included responsive instructional design to scaffold new content and promote independent learning (including lessons by Beth, Cindy, Emma, Kathy, and Sandy). For example, teachers included time for modeling, student exploration, and answering questions throughout their lessons. Five conceptual lesson plans included plans for clear, unbiased assessment (including lessons by Beth, Cindy, Kathy, and Sandy). Teachers included informal assessments to ensure student success and provided detailed rubrics that would allow students to self-assess prior to submitting their final product.

In one conceptual lesson plan, two middle school teachers planned to use game development to introduce middle school students to step-by-step algorithmic processes to write code. This lesson illustrated teachers' TPACK related to CS and CRP, satisfying all four of the content and pedagogy subcategories: CS content, pedagogical practices, instructional design, and assessment. Teachers began their lesson plan with a CS Unplugged activity that used dice to engage students in computational thinking. This activity encourages students to "think about specific steps it takes to play, which provides the foundation for programming" and ultimately transitions into skills for block programming in Scratch. Learning strategies such as pair-programming were included in the lesson to promote student collaboration. Together, students were assigned to watch a how-to video on CS First (https://csfirst.withgoogle.com) about how to create a "racing game" in Scratch. Teachers used appropriate disciplinary terminology throughout the lesson (e.g., binary, sprite, narrative) and encouraged students to use this terminology in their guided discussion and reflection questions.

To promote further collaboration and peer feedback, pairs could partner up with other groups to share their finished products. The lesson concluded with a whole class discussion and exit ticket, which provided students with the opportunity to reflect on what they had learned. Finally, a rubric was included in the lesson plan for students to use while self-assessing their projects. Overall, this lesson plan tailored appropriate CS content to students' knowledge and skill levels, provided the opportunity for collaboration, and included relevant assessment practices. This lesson plan included equitable practices such as incorporating real-world connections and extension activities that challenged students who met expectations.

Applied Understanding

After participating in the Summer Institute, teachers were able to successfully incorporate CRP into their own classrooms through adapting their learning environment design, pedagogical approaches, and course content to better serve their diverse populations of students.

Applying CRP in CS Classrooms

Findings from the online questionnaire revealed that teachers were able to retain their understanding of CRP and contextualize this understanding within their own classrooms and communities following the PD. Specifically, teachers continued to think about CRP in terms of cultural awareness, student-centered pedagogies, and equal access. In their discussions of cultural awareness, teachers held themselves responsible for understanding and adapting to cultural diversity in their classrooms. As Kathy explained, teachers must also understand "there are underserved populations in computer science due to bias." Mary also emphasized that teachers must translate their awareness into action: "Then, once the information is known [by the teacher], insisting on doing the best job to take the information into account and modifying [their] behavior."

Further, teachers emphasized the importance of student-centered pedagogies as an important part of culturally responsive teaching. According to Tara, "students' involvement in the application of computer science to their lives is key." She went on to explain that, in her experience, "many students respond to teaching that demonstrates computer science changing people's lives, such as wearable technology that helps someone with a disability complete the task." Finally, teachers noted the importance of CRP in promoting equal access. As Beth wrote, "Being a culturally responsive computer science teacher is making it important that all students in our schools have access to computer science opportunities." To this end, she created a CS club "where teachers encouraged students of all genders and ethnicities to join" (Beth). Throughout their responses, teachers emphasized the importance of *action* in being a culturally responsive educator.

Teachers reported using specific elements of CRP in roughly half of the lessons they taught. Creativity was the most used element, as four teachers reported using creativity "most of the time" and one teacher (Mary) reported "always" using creativity in her lesson plans. According to Tara, "There are so many opportunities for students to put their creativity to use, and there's more potential across all areas of the economy than many people realize." Real-world problem solving was the least utilized element, as

only two teachers reported "sometimes" using real-world problems and one teacher (Cindy) reported "never" using real-world problems in her lesson plans. When asked to provide examples of how they have implemented CRP, five teachers gave examples of how their lessons built on student interest and knowledge. Emma reported creating activities that "engage the students based on suggestions of topics they would like to cover." Three teachers reported designing activities that provided students the choice to incorporate their own interests. To support their use of CRP, teachers expressed the need for additional culturally responsive and grade-specific examples and resources.

Integrating CRP into Applied Lesson Plans

Applied lesson plans provide insight into how teachers applied CRP in their classrooms after participating in our Summer Institute (2019-2020 academic year). Specifically, we examined how teachers applied CRP when selecting content and pedagogical approaches in order to promote equity and inclusion in their own classrooms. As with the findings from the conceptual lesson plans, results are divided into two categories: (1) equity and inclusion, which examines how teachers applied CRP to address issues of culture, identity, exceptionalities, and social justice within their lesson; and (2) content and pedagogy, which examines how teachers applied CRP in adapting their content and pedagogical approaches within their own classrooms. Table 7 provides an overview of these findings in comparison with data from the conceptual lesson plans.

Equity & Inclusion. Teachers successfully incorporated elements of equity and inclusion into their applied lesson plans after participating in the Summer Institute. Five applied lesson plans incorporated cultural approaches in their design (Beth, Cindy, Deborah, Kathy, and Mary). For example, Beth encouraged students to develop a gaming story that incorporated specific references to their cultural heritage. Three applied lesson plans included aspects of authentic identity (Beth, Cindy, and Kathy). For example, Kathy encouraged students to work together to compare their cultural identities and create a visual display for the class. Three applied lesson plans emphasized CS identity as a way to promote a sense of belonging in the field of CS (Beth, Deborah, and Emma). For example, Deborah had her students decorate the classroom door with information about what CS looks like in the real world and why it is important. Three applied lesson plans included accommodations for student exceptionalities (Beth, Cindy, and Kathy). For example, Kathy used accessible websites that allowed for adjustments to the text display and included read aloud features for students.

One applied lesson plan included a social justice dimension to teach CS (Kathy). In this lesson plan, students explored the relationship between culture and climate change.

In her applied lesson plan, Kathy designed engaging activities for her middle school students that centered around world cultures and languages. First, she asked students to research the concept of culture and what it looks like around the world using reliable online sources. In this way, Kathy was able to incorporate diversity and make real-world connections. After the non-CS introductory activity, she led a whole class discussion about culture and the various cultural identities represented in their classroom. Each student had the opportunity to contribute by drawing on their own knowledge, perspectives, and experiences. Using pair-programming, students then coded projects in Scratch that incorporated their individual culture and heritage. Unique to this lesson plan, Kathy dedicated time to discuss collaborative group norms with her students. She also considered students' learning exceptionalities, intentionally choosing content that included pictures, videos, and audio clips to support multiple approaches to learning. By applying CRP, Kathy was able to create an impactful learning experience, which allowed students to collaborate with their peers and represent themselves authentically in their learning.

Content & Pedagogy. Findings suggest teachers successfully incorporated CRP into the content and pedagogy of their applied lesson plans after participating in the Summer Institute. All six applied lesson plans incorporated CRP into their CS content. For example, Emma incorporated appropriate CS terminology (CK) in her instruction and encouraged students to apply this terminology in their own write-up. All six applied lesson plans indicated the use of culturally responsive pedagogical practices. As in their conceptual lesson plans, many teachers relied on pair-programming to promote collaboration among students (PCK). Five applied lesson plans included culturally responsive instructional design in order to promote student learning and reflection (Beth, Cindy, Deborah, Emma, and Mary). For example, Beth and Cindy ended their co-taught lesson with a wrap up discussion, in which students reflected on their role as computer scientists and what they had learned from participating in the lesson activities. Five applied lesson plans included plans for equitable student assessment (Beth, Cindy, Deborah, Emma, and Kathy). Teachers included objective-based assessments, such as an exit ticket that asked students to draw their maze and write out the codes that they had used to guide a mouse through it.

In her applied lesson, Deborah demonstrated her understanding of TPACK and CRP by engaging middle school students in CS activities that

integrated creative expression and contemporary youth culture with coding. Her lesson began with a unique warm-up activity to encourage the formation of CS identities. Using her classroom door, Deborah asked students to fill the space with their ideas about what CS means and why it matters to them. Next came the dancing. Deborah designed this lesson to "combine coding with dancing in a creative way." Students danced in their own individual and creative ways to a playlist with music from a variety of different languages and genres. Next, students recorded themselves and watched a playback of their dance moves. Finally, students coded a dance party in Scratch following the sequence of their dance moves. They were encouraged to represent their individuality through their choice of dance moves and music. As Deborah explained in her lesson plan, "Learners of all ages get an introductory experience with coding and computer science in a safe, supportive environment." She also planned for how to address potential barriers depending on the dynamics of the classroom, such as varying reading levels and limited access to sound as the whole activity was designed to respond to music.

DISCUSSION AND IMPLICATIONS

In this work, we presented an approach to CS related PD encompassing essential features of effective PD (Darling-Hammond et al., 2017) along with key elements of CRP in order to better prepare teachers for effectively teaching CS content and engaging diverse populations of students. Our goal was to prepare educators to integrate CRP into their teaching practices by providing collaborative, active-learning opportunities to develop their CS knowledge and pedagogy for teaching CS in a manner relevant to their own teaching environments. The findings of this study provide critical insight into how culturally responsive and equity-focused CS PD can help teachers develop the beliefs (urgency) and instructional skills (agency) to design and deliver CS lessons that are both rigorous and inclusive.

Balancing Urgency and Agency

While the pilot version of this work emphasized the urgent need for increasing equity, diversity, and inclusion in CS, our second iteration emphasized both *urgency* and *agency* in order to shape teachers' beliefs and instructional skills (Goode, Ivey et al., 2020). After participating in the 2019

Summer Institute, teachers emphasized the urgency of adapting their pedagogy and curriculum to create equitable learning opportunities for all students, while also noting their agency to achieve these changes. They spoke of helping their female and racially minoritized students break down barriers in the field of CS. Teachers also articulated their belief that all students can be successful in CS education, while highlighting the use of student-centered pedagogies to encourage a sense of inclusion and belonging. By adapting our PD, we were able to help teachers develop their agency as culturally responsive CS educators. Agency empowers teachers to develop and maximize their capacity to accommodate for culturally diverse students adequately by adapting culturally responsive and equity-focused pedagogical practices (Goode, Ivey et al., 2020). Following participation in the 2019 Summer Institute, teachers integrated the instructional skills and pedagogical approaches that had been modeled during the PD. Findings revealed that teachers integrated CRP elements to support equity and inclusion into every lesson plan reviewed for this study.

Culturally responsive and grade-specific teaching practices are needed to bridge the diversity gap in CS, both academically and in the industry. The findings from this study reveal that our PD successfully established teachers' understandings around culturally responsive teaching practices in content, pedagogy, and beliefs. By participating in the PD, teachers became more aware of CRP in CS education, effectively strengthening their agency. Teachers carried experience from the PD into their classrooms, reflecting on and adapting the materials to meet the needs of their unique students within their own classrooms.

Findings from our work emphasize the importance of explicitly connecting PD with CRP elements in ways that both build teacher knowledge and empower action. As our findings indicate, knowledge of CS content and pedagogy does not suffice in efforts to broaden participation in computing. Rather, explicit attention on building teachers' knowledge of creating engaging learning environments that break down biases and build on students interests and cultural needs is essential. Therefore, we agree with Ryoo (2019) that PD designers should explicitly integrate CRP into PD programs in ways that help build teachers' repertoire of pedagogical practices to encourage student engagement with computing. Simultaneously, such programs must be accompanied by research and evaluation efforts that document changes in teachers' knowledge, practices, and beliefs. To date, few studies exist that document culturally relevant CS pedagogy in authentic settings, including instructional examples and student interactions (Madkins et al., 2019).

Providing High Quality Culturally Responsive and Equity-Focused PD

Our culturally responsive and equity-focused PD design successfully incorporated key elements of effective PD (Darling-Hammond et al., 2017) and our intentionally selected elements of CRP (see Table 2) to help teachers implement rigorous and inclusive CS instruction connected to their core curriculum. According to Darling-Hammond (2017), effective PD must incorporate a focus on content, active learning, collaboration, modeling, expert support, feedback and reflection, and take place over a sustained duration. While the importance of creating a PD that strictly focuses on content may seem obvious, it cannot be ignored. Our PD specifically focused on preparing teachers with the necessary knowledge and skills (CK) to integrate the CS principles (College Board, 2017) alongside their core curriculum. To this end, we engaged teachers in active learning throughout the PD to provide hands-on opportunities to apply their learning through practical activities, such as lesson planning. These opportunities ultimately enhanced teachers' own learning and, in turn, strengthened PD effectiveness (Bana & Cranmore, 2019). Throughout the week, teachers worked collaboratively to integrate the CS activities, pedagogical approaches, and computing tools presented during the PD into their own lesson plans (TPACK). Further, our PD successfully incorporated active learning strategies that prepared teachers to integrate CRP and CS into their core content.

For the 2019 Summer Institute, we redesigned our PD model to incorporate CRP into every element of our training and support. Findings suggest that this new model successfully improved the coherence of our culturally responsive and equity-focused PD. Throughout the PD, we modeled culturally responsive practices, provided expert support, and encouraged critical reflection grounded in the realities of teachers' classrooms and school communities. Each activity was designed as an opportunity for teachers to apply a culturally responsive approach to teaching CS to diverse populations of students. Additionally, we increased opportunities for collaboration among participating teachers. Collaboration allowed teachers to learn from one another and fostered an interactive learning community (Desimone & Garet, 2015). Activities were specifically designed for teachers to participate in small groups, which encouraged peer feedback and collective problem solving. Finally, our redesigned PD model improved the sustained duration of culturally responsive and equity-focused PD. We continued to expand the scope of our CRP training and support by preparing undergraduate facilitators to provide contextualized support during their field experience course.

Findings from this work emphasize the importance of continuous research and evaluation in efforts to build effective PD programs grounded in

the literature of effective PD. Specifically, PD programs could be strengthened through design-based implementation research efforts (Penuel et al., 2011) that focus on iteratively designing, testing, and refining PD programs. Such efforts will provide important feedback loops that leverage teachers' input, ensuring that PD is responsive to their needs. Ideally, such efforts should include classroom implementation data to ensure that PD produces positive and desirable CS outcomes among both teachers and students.

LIMITATIONS

There are two primary limitations associated with this work. First, our findings are based on a small number of teachers who volunteered to attend our CS PD program. As a result, they were already interested in learning and applying CS in their classrooms while addressing issues of equity. Second, despite the use of multiple data sources, the study did not include any direct measures, such as classroom observations. Nonetheless, lesson plans and interview data provided in-depth information about teachers' understanding of CS content, pedagogy, and CRP at both a conceptual and implementation stage.

CONCLUSION

CS education research indicates that teachers frequently hold deficit-oriented views about the fit between CS and students of color (Margolis et al., 2017). Thus, PD programs that help teachers learn about inequities in CS and how to incorporate CRP to make computing more inclusive are needed (Goode, Ivey et al., 2020). This study presents the outcomes and impact of our week-long Summer Institute on teachers' use of CRP in CS instruction. Findings indicate that teachers developed a strong foundational understanding of what it means to be culturally responsive and equity-focused. By offering teachers resources, training, and skill development during their participation in PD, we were able to effectively influence the way teachers will utilize culturally appropriate content, pedagogy, and CS tools. Previous models at the Summer Institute left teachers with a basic understanding of CRP and a thirst for contextualized support. Thus, although sessions were short yet intensive, the current PD model was able to successfully establish the importance of CRP and articulate the need for equity-based learning environments for diversity in CS.

Attending our Summer Institute helped teachers develop a strong foundational knowledge of what it means to be a culturally responsive educator and how to create an equity-focused learning environment. For teachers with repeated attendance, our PD established a lasting and influential impact on the way they use culturally appropriate instructional practices in their classrooms. This finding is important because literature shows that shifts in such teaching practices can support an equitable learning environment, provide encouragement and meaningful learning experiences to underserved students, and improve students' academic achievement (Bishop et al., 2009; Goode, Ivey et al., 2020; Prater, 2009).

Future research needs to follow teachers into their classrooms to understand and observe changes in instructional implementation and the implementation of CRP specifically (Mellom et al., 2018). Additional PD opportunities and CRP resources should be constructed around contextualized support for communication strategies, assessment practices, and challenges with student expression. Importantly, research should continue to build on best practices for teacher PD that respond to contextualized approaches and application of CRP.

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