

Culturally Responsive and Equity-Focused Computer Science Professional Development

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Abstract: The field of computer science continues to lack diversity, which has led to new efforts toward increasing access to computer science among all students. In order to address the underrepresentation of minoritized youth in computer science, we developed and delivered a culturally responsive and equity-focused computer science professional development model for helping teachers apply culturally relevant pedagogy alongside computer science principles within their classrooms. This paper focuses on how teachers experienced and processed this infusion of culturally relevant pedagogy into computer science professional development. Findings suggest that a teacher's context and experiences influence the ways in which they conceptualize culturally relevant pedagogy and plan to implement it into their classrooms.

Keywords: computer science education, teacher professional development, culturally responsive pedagogy

Introduction

Despite projections of increased jobs in all STEM (Science, Technology, Engineering and Mathematics) related fields and the acute projection of an increase in computer science (CS) related professions (Computer Science Teachers, 2013), schools are not adequately furnished to equip students with the knowledge and skill sets they need to meet these demands (Sengupta, Kinnebrew, Basu, Biwas & Clark 2013). The ubiquitous nature of technology in the modern world has led to many students becoming proficient in the use of technology in the role of consumer (Repenning et al., 2015). However, a lack of access to CS education has limited the knowledge and skills required to create new technologies to a much smaller, predominantly homogeneous subgroup of students, resulting in the underrepresentation of female and racially minoritized students in CS (Cuny, 2012). This underrepresentation highlights the need for a shift in CS teaching practices to attract, maintain and promote the success of all students (K-12 Computer Science Framework, 2016).

One way to create a shift in practice is to infuse culturally responsive pedagogy (CRP) in professional development (PD) efforts geared towards the teaching of CS. By helping teachers utilize CRP principles in conjunction with CS content and pedagogy, we may be able to attract more diverse students in the field of CS (Scott & White, 2013). Our culturally responsive approach to CS utilizes culturally relevant pedagogy (Ladson-Billings, 1995) and culturally sustaining pedagogy (Paris, 2012) in order to design and deliver a PD program which helps teachers create CS learning environments that serve underrepresented minoritized and female youth. According to Gay (2010), CRP “validates, facilitates, liberates, and empowers ethnically diverse students by simultaneously cultivating their cultural integrity, individual ability, and academic success” (p. 46). Specifically, CRP is an approach to teaching that focuses on valuing, nurturing, and promoting cultural identity within the classroom (Villegas & Lucas, 2007).

To become culturally responsive, teachers must engage in self-reflection to examine their own biases regarding their perceptions of students' intellectual abilities based on race, gender, and socioeconomic class (Howard, 2003). In developing and delivering our culturally responsive and equity-focused PD, we were guided by an overarching question of whether we could successfully communicate a framework for culturally responsive and

equity-focused CS to teachers in a relatively limited timeframe. For the purposes of this paper, we examined the following research questions:

1. How are teachers making sense of CRP and equity in the context of a PD program focusing on the teaching of CS?
2. How do teachers expect to apply this culturally responsive and equity-focused PD in the context of their individual schools, communities, and classrooms?

Description of PD Model

In an effort to help teachers incorporate CS principles into K-12 classrooms, our research team initiated a CS partnership program supported by a series of grants from the National Science Foundation since 2012. This partnership incorporates a three-tiered approach to support teachers as they learn to integrate CS principles across a variety of K-12 curricula: (a) an annual week-long Summer Institute, (b) a college field experience course in which undergraduate students with background in CS assist teachers in developing and implementing CS lessons, and (c) sustainable partnerships with local public and private schools (Fig. 1). The scope of this paper is limited to one iteration of our Summer Institute.

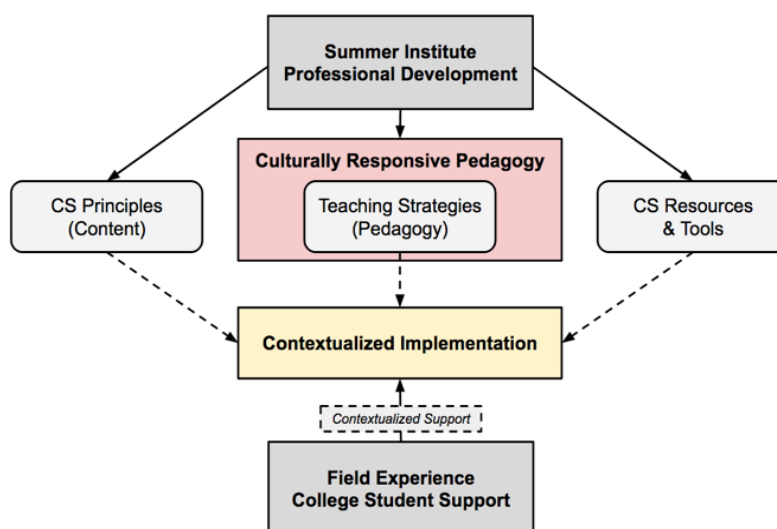


Figure 1: Culturally Responsive PD Model

Summer Institute

Our university partnership with local schools and teachers begins when teachers take part in our Summer Institute, a week-long opportunity that has been held annually since 2012. Since its inception, the popularity of the Summer Institute has grown substantially, requiring teachers to apply for a limited number of spaces. In the summer of 2018, 77 teachers applied, 44 were accepted and 33 eventually attended the Summer Institute.

Of these 33 participants, nine were male and 24 were female. Participants taught primarily middle and high school students, but teachers ranged all the way from K-12. Participants taught a range of subjects, including core elementary, business, technology, mathematics, library and stand-alone CS classes. Participants hailed from 26 different schools, six private or parochial, 20 public and one public library. The program was split into two tracks: *Integration Track* (N=23) and *Computer Science Principles (CSP) Track* (N=10). The Integration Track is geared towards teachers who do not teach stand-alone CS classes but are interested in infusing principles from CS across other STEM curricula. In contrast, the CSP Track is intended for high school teachers who are tasked with the delivery of stand-alone CS courses, primarily the new Advanced Placement (AP) CS Principles course. Although participants have different and track-dependent work, the overall goals for both tracks are the same: (a) learn CS

content and pedagogy, (b) gain confidence in integrating CS principles, (c) build a community of practice, and (d) identify recruiting and retention strategies that help broaden participation in computing.

The PD sessions were run by a combination of university faculty members, graduate students, and local teachers who had been long time partnership participants and excelled at implementing CS principles into their own classes. Each day, the program facilitators modeled effective classroom strategies for CS integration while the participants took on the role of their students (Tab. 1). In these sessions, program facilitators employed CS unplugged activities designed to teach CS principles such as networking, cybersecurity, data transfer, and programming through activities devoid of technology. Additionally, participants were introduced to a diverse set of CS tools including Edison Robots, Scratch, Ozobots, Micro:bits, Finchbots, MakeyMakey, and Arduino Kits. After familiarizing themselves with these CS principles and tools, teachers worked in groups to develop lessons that integrated the CS principles and tools of their choice and meet state standards for their specific content areas. The participants shared their ideas with their cohorts, offered and received feedback, and adapted their lessons to better meet their goals.

Table 1: Summer Institute PD Schedule (*Integration Track*)

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9:00-10:15	Introductions, Program, Overview & CS Unplugged - <i>Icebreaker</i>	Scratch and Paired Programming	Data Evaluation & Sources Unplugged - Outbreak Data Power & Sources	CS Toys: Exploring Computational Curriculum	Lesson Development
10:15-10:30	Break				Lesson Sharing
10:30-11:45	Introduce CSTA Standards, Ex Lesson Unit: <i>Mars Rescue</i>	Creativity with Scratch	Cybersecurity & Data	Culturally Responsive & Lesson Development	
11:45-12:30	Lunch				Adjourn
12:30-1:00	Broadening Participation in Computing	Culturally Responsive	Broadening Participation in Computing	CS Unplugged - <i>Network Simulation</i>	
1:00-2:15	Continuation of <i>Mars Rescue</i> & Discussion	CSP: Creativity - Assessing Programs for Learning & Creativity	Micro:bits & CS Unplugged - <i>Hack-A-Ball</i>	CSP: Internet - Teaching Web Programming	
2:15-2:30	Break				
2:30-3:45	Culturally Responsive & Lesson Planning	Lesson Development & Peer Feedback	Culturally Responsive , Lesson Development & Peer Feedback	Projects for Web Programming	
3:45-4:00	Reflection on Learning	Reflection on Learning	Reflection on Learning	Reflection on Learning	
4:00-4:30	Adjourn & Individual Consultations				

Culturally Responsive Framework

While the incorporation of CS principles into lessons drove the PD sessions, special attention was paid to including culturally responsive and equity-focused teaching practices into training sessions each day (Fig. 2). Each of these sessions lasted approximately 30 minutes. This focus on CRP and equity offered participants insight into why traditionally underrepresented groups, such as racial minorities and female students, may feel left out in CS classrooms. Additionally, teachers were introduced to useful techniques for attracting, maintaining and engaging students from these underrepresented groups. Specifically, we sought to address the underrepresentation of minoritized youth in CS by utilizing culturally responsive frameworks that integrate knowledge relevant to youth identities and communities with computational learning activities (Ladson-Billings, 1995; Nieto, 2002). This paper focuses on how teachers experienced and processed this infusion of CRP and equity into our CS PD.

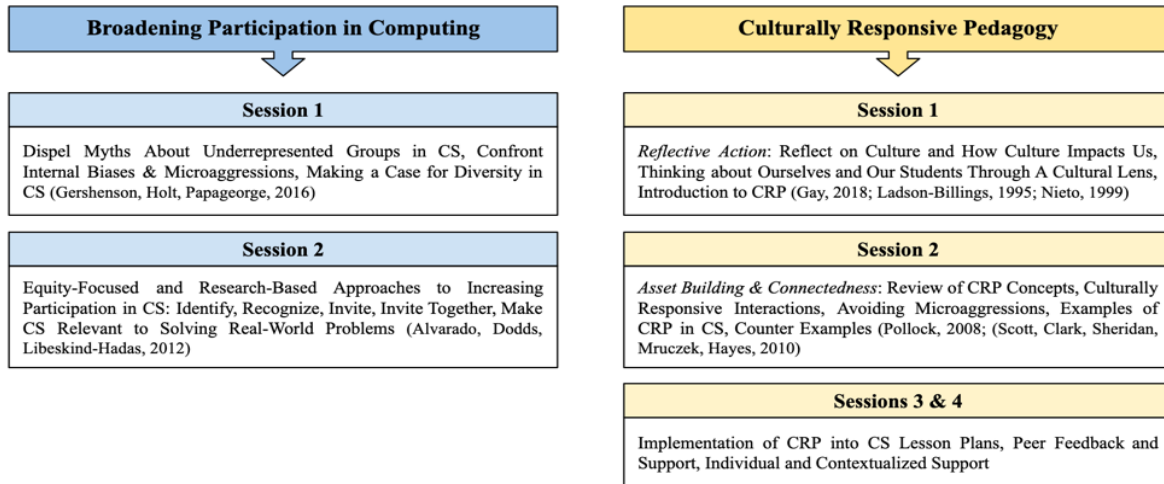


Figure 2: Culturally Responsive and Equity-Focused PD Sessions

Methods

Participants

In this work we focus on the Integration Track participants (N=23) who taught primarily at the K-8 level. We focus on this age group because research says it's at the middle school level that students decide if CS is worth exploring (Bruckman, et al., 2009). Of the 23 participants in the Integration Track we used criterion sampling to recruit participants who work primarily with minoritized students in a racially and socioeconomically diverse school (N=15). Of the 15 requests, 11 teachers agreed to be interviewed on the final day of the summer PD. While the 11 teachers in this study are all female, they vary in grade level taught, race, and teaching experience (Tab. 2). All 11 teachers typically taught core elementary, business, technology, or library classes at their respective schools. Several teachers also taught after-school CS programming.

Table 2: Participant Demographics

Pseudonym	Race	Gender	Years Teaching	School Level
Kathy	White	Female	21	Middle School
Mary	White	Female	20	Elementary School
Veronica	Black	Female	13	Middle School
Deborah	Black	Female	6	Charter School (P-8)
Tammy	Black	Female	21	Middle School
Amy	Black	Female	2	Charter School (K-8)
Sharon	White	Female	8	Elementary School
Cindy	Asian	Female	11	Elementary School
Gabby	White	Female	4	Elementary School
Janet	Black	Female	15	Elementary School
Gina	Black	Female	18	Middle School

Data Collection

Qualitative data were collected through semi-structured interviews with each individual teacher. Interviews were conducted by professionals from an education research center, with no PD organizers present, allowing participants to voice their ideas freely. The interview protocol included nine questions that focused on teachers' experiences in the PD, the effectiveness of culturally responsive sessions, and their need for follow-up support. The four culturally responsive questions asked teachers to: (a) define CRP, (b) identify the connection between CRP and

CS, (c) give an example of how students can use technology to solve real-world problems in their community, and (d) explain how they will apply what they learned about CRP to adapt their curriculum back in their schools. Interviews were conducted in a private room following the conclusion of the final day of the summer PD and lasted approximately 15-20 minutes depending on each participant's responses. All interviews were recorded and transcribed for analysis.

Data were analyzed to identify common and unique themes, using an analytical approach inspired by grounded theory (Glaser and Strauss, 1967) and data were coded based on emergent themes and categories. The themes were categorized into three overarching categories: conceptualizing CRP, implementing CRP, and parting perceptions.

Findings

Findings suggest that we were able to successfully communicate the need for equity and cultural responsiveness to CS teachers during our week-long Summer Institute. However, teachers' conceptualizations of CRP and how they plan to implement CRP in their classrooms varied greatly depending on each teacher's individual context, experiences, and world view.

Conceptualizing Culturally Responsive Pedagogy

When asked to define CRP, responses fell into three categories. Teachers either defined CRP as their own sensitivity and awareness of diversity, diverse cultural representation and student choice in the curriculum, or the creation of a welcoming and encouraging environment for minoritized students.

Sensitivity and Awareness

One of the themes that emerged was the concept that CRP is an orientation of the teacher towards sensitivity and awareness of diversity. Kathy defined CRP as "just being a human and understanding that people come from different—things happen differently." She went on to say, "It's not even all about race or gender. There's many different aspects to culture that define you, and that we have to be sensitive to all those things." Kathy defined CRP as sensitivity grounded in humanity. Similarly, Deborah understood CRP as "being more aware of other people around us. I think we all grow up knowing that we should be more considerate of people... I think it is a way to reassure that person, 'You can be who you are in your circle and there will be no judgment.'" Like Kathy, Deborah saw CRP as emerging from an innate compassion for others brought on by an awareness of those around you.

Developing awareness includes addressing personal bias. Gabby defined CRP as being "especially about the inner bias" and said that she tries to always be aware of her expectations, keeping them high for all students, and by watching her language. While Gabby is aware that she has internal biases, she is not sure how to go about addressing them. "[CRP includes] 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," Gabby said, laughing. She knew addressing internal bias was an important part of CRP, but she was not sure where or how to start.

Cultural Representation

Another theme that emerged was the connection between CRP and the need to represent students' racial identities and cultures within the CS classroom. Janet defined CRP as developing lesson plans and other materials that "reflect the look of the students that are in the room." She went on to say that the purpose of CRP in CS is "to show kids of different backgrounds and abilities that they can do it." According to Sharon, CRP is "making your instruction and the materials accessible and relatable to them in a way that won't hold them back." Janet and Sharon understood CRP creating opportunities for cultural representation.

Several teachers identified student choice and creativity as other ways to allow for more representation in their assignments. For example, Amy described CRP as when students "can incorporate some of their stuff, whatever language or background they have, in whatever it is that we do. Just allowing them to be a little bit more creative." Amy saw a unique opportunity in CS for this approach to CRP: "With computer science you can be really

as creative as you want. To me it's kind of broad, but at the same time, you can bring your own flavor, or experience, or background into it." They saw CSP as allowing more creativity and choice in their CS assignments.

Welcoming Environment

The third theme that emerged was an emphasis on creating a welcoming environment to address the underrepresentation of female and racially minoritized students in CS. "I think [CRP] is definitely needed because computer science, historically, has been seen as white males or Asian guys," said Sharon. "Especially for girls, I think it's important." Amy also picked up on the importance of diversifying CS: "All week we've been talking about Computer Science and how it's mostly dominated by the white male. And then when you add females into it – we bring so many different ideas."

In order to increase diversity, teachers suggested creating welcoming learning environments. According to Tammy, "[CRP] has everything to do with the structure of the learning, the environment . . . Because you have diversity within your classroom . . . not just in race but in religion and learning abilities." Tammy understood CRP as a way to make sure all of her students are comfortable in learning about CS. Similarly, Veronica saw CRP as building an inclusive classroom: "If you had culturally responsive in your ways of teaching you're going to – for computer science it's going to automatically be more inclusive and you're going to have more diversity."

Implementing Culturally Responsive Pedagogy

Teachers were asked to give an example of how their students could use technology to address real-world problems in their own communities. While several teachers were able to envision applications of technology as a tool for change, others suggested more simplistic connections between CS and altruism. How teachers answered this question was impacted by how they conceived of students and communities in their individual context.

CRP in Context

Asking teachers about solving real-world problems placed CRP within the context of their classroom. How teachers conceived of their students and communities impacted how they answered this question. For example, Gabby thought about the limitations of her elementary students, believing they were too young. "It's not like they're high school," she said. "It's not like they could go out and start a movement." Gabby saw age as a limitation for engaging students in real-world applications of CS in their communities. Mary also saw limitations, described her students as unable or unwilling to use technology to address real-world problems: "Their communities are really crappy. They don't see them as crappy, they see them as lovely, lively places to live. I think it would be very difficult for me to define what would make their communities better from their perspective. So, could they use technology? Sure, they could use their cellphones to film the crimes as they happen and get them prosecuted. But they never do that. Never do that. They will film the crimes as they happen to pass around as entertainment." Mary took a deficit view of her students (Solorzano, 1997), which causes her to believe they are unable to use technology as a tool for change.

Like Mary, Cindy also works in a high poverty school. However, she conceives of her students and their community in a more culturally affirming way. While thinking about how her students could address the lack of recycling in their community with digital storytelling, Cindy reflected on her students and their community through a culturally responsive lens: "A lot of kids do not care about [recycling] because they have other issues going on at home. And I have to be aware that it may not be a top priority for the family. And I think that some families have much more relevant issues and problems happening at home. And some of them do not even have a home." She is not deterred by their lack of interest in recycling. Instead, Cindy tried to think of ways she could teach the students about recycling: "We could take a field trip to the recycling center. I can just do mini lessons with them about watching the videos of what actually happens, looking at the statistics of where the garbage goes, and what happens to the garbage in landfills."

Mary and Cindy both work in high poverty schools and they both describe their students as lacking the confidence to take risks. Mary explained that she has to scaffold what she teaches her students "because they've always failed." However, Cindy framed the issue more positively: "I am working at a Title I school with a high percentage of kids living in poverty. And I think there is always issues with confidence. And I think there is always

issues with kids not feeling safe to make mistakes. So, I want to try to build up, through the after-school program, and expand that. And make sure that we are making all students feel successful.” Mary and Cindy are an example of what the PD was unable to change, which is how teachers viewed their students. Cindy offered a stark contrast to Mary’s deficit view of her students. How each teacher described her students seems to be a combination of past experience and world view—or at least their interpretation of student motivation.

Tool for Change

Several teachers gave engaging examples of how their students could use technology as a tool for change in their communities. Veronica suggested that her students could survey the community to collect and analyze data to address *food deserts* in their neighborhood. She was aware of a community problem and thought her students could benefit from answering questions like, “How far is the nearest grocery store that sells good food, not, you know, junk, or high-priced food”? Similarly, Gina suggested that her students could develop an app to address issues of clean water and water filtration. While she wasn’t sure exactly what the app would do, she was aware that access to clean water is an issue many communities are facing. Another teacher, Tammy, also thought about ways her students could support the ongoing community by creating interactive presentations and videos to support charitable work.

While other teachers drew on community-based problems, Janet gave an example of how her students could help solve a real-world problem within their own classroom by helping a student who is progressively losing his sight: “So, to be more sensitive to his needs and maybe developing resources and apps and technology available, that it be readily available for him as he’s progressing in his disability.” Janet wants her students to use technology to make sure this student can come in and effectively work and not have to worry about anything else going on.” Janet saw the potential for her students to be involved in helping create a classroom environment to meet the needs of their classmate.

Cindy thought out loud while answering this question, providing insight into how she incorporated both the culturally responsive and technology pieces into her proposed recycling project: “So, culturally responsive – this neighborhood is a different neighborhood than I am used to, but I want to reach out to the community and say this is something that we can all do. And that this is the value of it. And I hope through the after-school clubs to try and bring in. How would I use technology for that? I am not sure. I think that we can do some stories – recycling stories – on Scratch. And maybe present them to families. Maybe invite them in. The kids can do their own little research project. And I also use Seesaw. So maybe we can incorporate – can take videotapes, they can write, and they can do selfies and video. So I want to incorporate those and maybe do a digital story – a recycling story – and then invite the community.” Cindy combined her knowledge of the community with her past experience in teaching CS to develop several possible projects that would help her students use CS as a tool for change.

Charity Without Change

A third theme emerged was the inclusion of altruism without technology or computing. Deborah suggested having her students collect and donate items to charity, but she did not connect the idea back to technology or CS principles. While her students would be doing a good deed, they would be addressing a need more than solving a problem or creating change. Amy also thought about CS as a way to engage and help bring hope to the community. She gave an example of taking her students to share CS projects with kids at a hospital, “but maybe giving them the opportunity to learn more about computer science and give them a little bit of hope, if anything.” Teachers whose responses fell into this category seemed to feel limited by their specific context.

Parting Perceptions

While many teachers described leaving the week-long Summer Institute feeling well-informed about CRP and motivated to implement it in their classrooms, other teachers described lingering frustrations with how to implement CRP and a desire for additional help and resources.

Motivated & Informed

Teachers left the PD feeling like it is their responsibility as teachers to help increase diversity in the field of CS. Several teachers were inspired to action. Cindy wanted to start a Girls Who Code club afterschool, “because there was a lot of discussion about cultural responsiveness and I think that in order to recruit females and minorities we really have to go out and invite them.” Other teachers were inspired to make changes within themselves. Veronica learned about “those micro-aggressions” from the PD. “I didn’t realize that was a thing, so now I’m more – now that I know – you know that thing, you know better you’ll do better.” Another success was that the PD was able to contextualize CRP within CS. Teachers like Gabby were made “more aware” during the PD: “I’m at an inner-city school, so I was already aware and got a lot of training. But I like hearing the computer science aspect of it. I want to be more aware that I am a white teacher and I am teaching 80 or 90 percent African Americans.” While they each picked up on different aspects of the training, it was clear that all 11 teachers left with new knowledge about CRP.

Frustration & Desire for More

While we had many successes, several teachers also mentioned lingering frustrations during their interviews. Several teachers left wishing we had given them *more*. Veronica was very excited about CRP during her interview, but she felt that she had to learn some of it on her own: “I googled it and I learned more from the articles I read than from the presentation.” Although she was disappointed that the PD did not offer more answers, she was inspired to learn about CRP independently. Janet also expressed a need for the PD to address real-life issues teachers are facing in classrooms, such as meeting the needs of her students with physical disabilities. Cindy also asked for intersectional support with issues such as special education, learning disabilities, and low-income communities.

Conclusion

In this work, we present the outcomes of the culturally responsive and equity-focused elements of our week-long Summer Institute for CS teaching. Our findings indicate that this PD model was able to successfully contextualize CRP within CS and to communicate the need for diversity in CS. Specifically, findings indicate that even though our CRP training sessions were short, teachers left the PD with a strong foundational understanding of what it means to be culturally responsive and equity-focused as a CS teacher. By contextualizing CRP within our CS PD model, we were able to influence how teachers will implement the content, pedagogy, and CS tools. However, the short-term nature of the CRP element in our overall PD did not allow us to offer a more in-depth training in CRP. This resulted in teachers with only a shallow understanding of CRP and feeling frustrated or unable to implement CRP in their own context. It also limited our ability to address teachers’ deeply rooted beliefs about their students. In our research, we have also begun to address the implementation of CRP into our contextualized support by working with our college students to build a framework for culturally responsive and equity-focused support. Future research needs to examine how teachers are implementing CRP within their classrooms following the PD and identify ways for scaling up our contextualized support to provide additional CRP resources for designing and adapting lessons.

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