

Preparing Cybersecurity Camp Facilitators to Be Culturally Relevant Mentor Teachers

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Abstract

This study analyzes how mentor teachers perceive the professional development of culturally relevant pedagogy (CRP) in STEM informal learning spaces, e.g., afterschool programs, and analyzes the support needed to nurture practices of CRP. Additionally, the study investigates how culturally relevant professional development (CRPD) influences mentor teachers' use of CRP theory into practice to advance racial/ethnic and gender equity through an informal cybersecurity camp. This study employs critical arts-based methods, specifically the Theatre of the Oppressed methodology, to promote the implementation of culturally relevant pedagogy through a critical perspective. The qualitative data analysis (semi-structured interviews) provides an overview of the Fall 2022 session of a year-long multi-state virtual cybersecurity camp funded through the Defense STEM Education Consortium. Participants with prior experience as teachers in informal STEM camp settings were recruited from both the East and West Coast regions of the United States through an online application process. The data sample is composed of 10 ethnically and racially diverse participants consisting of undergraduate, graduate, in-service teachers, professors, and industry professionals. Findings reveal that multiple and comprehensive CRPD sessions elucidated mentor-teacher interpretation of CRP and the implementation of CRP practices. Future research on CRPD in STEM informal learning spaces is briefly discussed.

Keywords: culturally relevant professional development, culturally relevant STEM pedagogy, informal STEM camps, mentor teachers

Introduction

Dismantling pedagogical barriers to equitable science, technology, engineering, and mathematics (STEM) education through informal STEM programs that focus on culturally relevant practices can develop STEM capacity and close achievement gaps for underrepresented students by race and gender (Young et al., 2019). Professional development (PD) of culturally relevant STEM pedagogy re-imagines the culture of STEM education to critique forms of oppression (e.g.,

racism, sexism, classism, ableism) and seek social change (Eubanks-Turner et al., 2018; Kendricks & Arment, 2011). The ongoing trend of STEM jobs outpacing the number of qualified workers (Funk & Parker, 2019) has given rise to funding and sponsorship of informal STEM learning spaces that broaden participation by race and gender by emphasizing student identity development, attitudes, and career interest (NSF, 2023). Informal STEM learning spaces, such as afterschool and summer programs, are educational environments outside the traditional classroom setting. In these spaces, learners of all ages can engage in a diverse range of STEM-related activities and experiences. Bolstering informal STEM teacher competencies in culturally relevant pedagogy advances equity in ways that nurture STEM identity in girls of color (King & Pringle, 2019). However, responses to the needs of the STEM workforce often view the solution to disrupting racial and gender inequities as occurring through experiential STEM activities (Neve & Keith-Marsoun, 2017) and content knowledge development (Carver et al., 2017). Such shortsighted approaches can hinder equity in STEM education when the evaluation of equity is rooted in symbolic and political representations of inclusion practices rather than a lens to critique biases or forms of oppression (Boyce, 2017). Although studies confirm a relationship exists between teacher identity and how they learn to teach (Adams, 2020), the information on teacher preparation to engage with culturally diverse learners in informal STEM camps is sparse (Yerrick & Beatty-Adler, 2011). Therefore, removing barriers to student participation, as it pertains to race/ethnicity and gender, in STEM education through informal STEM programs (e.g., virtual cybersecurity camps) requires examining the methods used to prepare facilitators as culturally relevant mentor teachers and, in this study, cybersecurity facilitators.

In the United States, the high enrollment rates of school-aged (6–12 years old) children from Black and Brown communities in afterschool STEM programs demonstrate an existing interest and demand for such educational opportunities. According to the Afterschool Alliance (2020) report, during the 2019 summer, 272,032 children participated in an afterschool STEM program that

exposed K-12 learners to career opportunities, hands on activities, and running experiments. Characteristics of most informal learning spaces are the essential supports, such as individualized versus standardized learning expectations, and inquiry-based projects that allow students to discover and explore interests. Whether these supports are the reasons for greater participation among African American and Hispanic children than Caucasian children in after school programs, or likewise girls' attendance being the same as boys, can only be assumed. On average, K-12 students spend more than 80% of their time outside of school learning in afterschool and summer programs in libraries, science centers, and STEM programs, compared to just 20% of 16 waking hours spent in school (Afterschool Alliance, 2020). Yet, Black and Brown communities, unmet demands for afterschool programs contribute to race/ethnicity participation disparities (Afterschool Alliance, 2021)¹. As such, informal STEM programs have the potential to diversify and transform the culture of STEM education. This qualitative study reports how mentor teachers participating in culturally relevant professional development (CRPD) for an informal five-week cybersecurity virtual camp interpret and reflect on culturally relevant pedagogy to advance equity in STEM education.

Literature Review and Theoretical Framework

Informal STEM Professional Development

Informal STEM learning environments have become viable opportunities to examine STEM teacher attitudes about integrating engineering into their classrooms (Dailey et al., 2018), the impact on their scientific content knowledge skillsets (Aaron Price & Chiu, 2018), and the progress period for teachers to learn the skills to be effective STEM teachers for diverse learners engaging in an informal STEM class (Kim & Keyhani, 2019) through professional development. Professional development as a medium for knowledge transfer has the reputation of being a change agent, such as in teacher content knowledge, confidence, and awareness of learning styles (Aaron Price & Chiu, 2018). Working with grade 3–5 students

¹ The total values exceed 100 percent because respondents were able to select "all answers that apply".

in a day camp, Dailey et al.'s (2018) teacher professional development study investigated teacher attitudes as a result of their experiences learning how to integrate engineering in the classroom. Teachers were provided up to 26 hours of PD as part of the study, which included learning about differentiated instruction, assuming the role of a student when guided through the lessons, and hands-on experiences. Findings from the study revealed statistically significant improvements in the teachers' attitudes about engineering. While Dailey et al.'s (2018) study offers a perspective of informal STEM professional development's transformative potential on STEM teacher attitudes, it does bring awareness to the need for more STEM teacher supports as part of the ecosystem in STEM education to close the gaps in achievement and workforce demands.

Informal STEM program goals for underserved student populations, in general, seek to prepare teachers for teaching STEM concepts that respond to achievement and engagement gaps (Yerrick & Beatty-Adler, 2011). For instance, professional development to bolster teacher self confidence in designing and implementing cybersecurity related content has grown in K-12 cybersecurity education programs (Childers et al., 2023). Studies on the impact of professional development for cybersecurity teachers in informal spaces, however, are hard to find. Rather, focusing on cybersecurity skills shortage has prompted studies on cybersecurity professional development in formal and informal spaces to cultivate a lifelong learning mentality (Stavrou, 2023). Such examples emphasize the need for studies specifically on informal teacher professional development in cybersecurity that combine social issues with content knowledge to produce equitable STEM teaching outcomes.

The flexibility of informal STEM programs in the delivery of STEM content, compared to formal school frameworks that reify traditional approaches to teacher education, can shift teacher mindsets toward equitable teaching in the implementation of content (Dailey et al., 2018). In light of the subjugation of women and people of color in STEM education (Alfred et al., 2019; Nkrumah, 2022), initiatives, such as informal STEM PD for programs targeting marginalized populations, raise awareness of the inequities in traditional STEM education from teacher pedagogy (Charity Hudley & Mallinson, 2017). Further, STEM teacher PD studies of informal camps that look to adjust teacher implementation of STEM content (Hayden et al., 2011) bring attention to the structural barriers that hinder academic and workforce success for people of color.

Culturally Relevant Pedagogy in STEM Education

Growing research interests in STEM education, such as culturally relevant pedagogy (CRP), highlight the diverse perspectives contributing to the inequities as well as the purpose for implementation in the literature (Boutte et al.,

2010; Garvin-Hudson & Jackson, 2018; Johnson & Elliott, 2020). Increasing culturally and linguistically diverse student populations emphasize the need to transform how teacher education programs prepare future STEM educators (Mark & Id-Deen, 2022). In addition, STEM workforce demands for skilled employees have prioritized efforts to improve the supports in STEM programs that would retain aspiring scientists and engineers from racialized groups in the field (Chang et al., 2014). Regarding students of color—non-English speaking is the lowest represented group in STEM education and the workforce, particularly in cybersecurity (Mountrouidou et al., 2019)—CRP focuses on inclusive instruction, which helps to address the limitations in how to engage students from non-dominant groups. Therefore, learning how to transfer CRP's theory into practice appears to be the solution for this limitation.

According to Ladson-Billings (1995), CRP fosters equitable teaching and learning in education. To this point, Ladson-Billings details the attributes of "good teaching" in her analysis of habits performed by the racially diverse teachers of African American students and characterizes CRP based on the following three tenets: (1) academic success — ensuring students develop their academic skills, regardless of current social inequities; (2) cultural competence — ensuring students maintain some cultural integrity and academic excellence; and (3) critical consciousness — ensuring students learn to critique social and cultural norms as part of their sociopolitical consciousness development. Studies about STEM education represent a level of confidence in CRP as a framework to address learning gaps in STEM education that perpetuate inequities along race and gender lines (Brown et al., 2019; Mark & Id-Deen, 2022).

CRP is a credible solution because its framework explicitly outlines the process for teaching with equity in mind. For example, Mark & Id-Deen's (2022) study with pre-service teachers hones in on the role of teacher education programs in breaking the cycle of inequities in the instructional practices of STEM teachers that lack cultural relevance. Identifying the importance of advancing CRP in a methods course exposed the roadblocks to teacher beliefs about cultural diversity, its influence on student learning outcomes, and the inability to implement the theory into practice. Similar to Boutte et al.'s (2010) study addressing pedagogical limitations to culturally relevant science teaching, Mark & Id-Deen (2022) observed how the superficial implementation of CRP reinforced the misconceptions that the application of CRP somehow reduced rigor in STEM. For example, research by Mark and Id-Deen (2022) highlights the superficial implementation of CRP strategies by pre-service teachers, such as the standardized approach of grouping students according to perceived learning styles (e.g., kinesthetic, auditory) has been widely debunked as an ineffective and oversimplified method for promoting

academic success. This type of one-size-fits all strategy fails to account for the learners' cultural background, prior experiences, and individual learning preferences. While exposing limitations in the understanding and interpretation of CRP, for example, Underwood & Mensah's (2018) work with four science teacher educators underscored how underdeveloped among the three tenets critical consciousness was in the enactment of CRP. The challenges to fully develop science teacher implementation of critical consciousness reflects a need in teacher education programs. Madkins & McKinney de Royston's (2019) CRP study, for example, makes the case for critical consciousness development for science educators to recognize how racism contributes to students of color underrepresentation in science. More importantly, there exists a need for studies that reveal the impact of CRP from a student's perspective (Hubert, 2014), and on teacher application of CRP following professional development, to overcome the elusiveness of putting this theory into practice (Brown et al., 2019; Garvin-Hudson & Jackson, 2018).

Research Questions

Apparent from the literature on culturally relevant STEM pedagogy are the unique and non-traditional approaches for engaging students from racially diverse backgrounds in STEM education that reify equitable learning outcomes. From the context of an informal cybersecurity camp, this study seeks to learn participant perceptions of CRP in STEM and to understand what resources facilitators who are prepared as mentor teachers need to nurture their practice of CRP in STEM. The overarching goal of this study is to explore the influence of CRPD on advancing racial/ethnically diverse and gender equity through an informal cybersecurity camp. Last, the study investigates a CRPD model for preparing facilitators to operationalize the transfer of theory into practice. The research questions (RQs) guiding this study are as follows: (RQ1) How do mentor teachers for an informal cybersecurity camp interpret culturally relevant pedagogy? and (RQ2) What do mentor teachers' reflections reveal about culturally relevant pedagogy?

Methods

Study Context: Culturally Responsive Cybersecurity Camp

Funded through the Defense STEM Education Consortium (DSEC), this study reports on the Fall 2022 MT cohort session of a yearlong multi-state virtual cybersecurity camp designed for girls of color, ages 12-18. The informal STEM camp relies on culturally relevant and culturally responsive frameworks in the curriculum design and the camp facilitator preparation process. The camp with its culturally responsive computing curriculum was created as a social justice project to challenge false

CRPD Session	Lesson Topics	Description
1	Theatre of the Oppressed	Through the arts, mentor teachers (MTs) experience various oppressions in computer science/STEM education to rehearse disrupting them and learn equitable teaching practices.
2	Sociocultural Consciousness Development	Using collaborative exercises, MTs learn to examine the inequities that shape the culture of computer science/STEM and how to position the learner as producers of knowledge.
	Affirming Attitudes Toward Culturally Diverse Learners	
	Commitment & Skills to Act as Agents of Change	
3	Constructivist Views of Learning	Focusing on reflexivity and student-centered approaches, MTs actively translate theory into practice from scripted prompts and scenarios, in order to normalize CRP.
	Learning About Students	
	Culturally Responsive Teaching Practices	

Table 1. Culturally Relevant Professional Development (CRPD Structure and Curriculum)

narratives that girls of color lack talent or interest in computer science education, specifically cybersecurity. Therefore, it is a priority that camp facilitators, named mentor teachers (MTs), acquire the necessary skills to implement a culturally responsive computing curriculum and foster participant development as technosocial change agents (Scott & White, 2013).

In September, MTs for the Fall 2022 camp virtually

attended three CRPD sessions facilitated by the author. The virtual setting was ideal for this study because participants were in Arizona, California, and Maryland and this format made it convenient for them to attend after college classes and jobs. The CRPD sessions were interactive with a blend of whole group discussions, breakout room exploratory activities, roleplay, reflexivity exercises, and most importantly, relationship building opportunities

Name (Pseudonyms)	Gender	Ethnicity/Nationality	Major or Profession
Cora	Female	Nigerian	Computer Science/Undergraduate
Lynda	Female	African American	Business/Undergraduate
Rae	Female	Sri Lankan	Computer Science/Doctoral
Anthony	Male	Nigerian	Applied Mathematics/Computer minor
Marc	Male	Hispanic	Project Specialist, Work Based Learning/CTE Educator
Ada	Female	Filipino/White	Computer Science/Undergraduate
Anne	Female	European American	Digital Culture
Kena	Female	Indian	Computer Science/Graduate
Monique	Female	Nigerian	Computer Science/Professor
Elaine	Female	European American	K-12 Cybersecurity/Teacher

Table 2. Demographics of Mentor Teachers

using icebreakers or Theatre of the Oppressed gaming activities (Boal, 2021). The lesson topics varied for the CRPD curriculum to focus on underutilized unique aspects of the culturally relevant pedagogy theory, such as sociocultural or critical consciousness development (see Table 1). Each week after the three CRPD sessions, the MTs convened for a virtual group meeting on Thursdays. These 90-minute sessions took place before the Saturday cybersecurity camp to equip the MTs with knowledge and understanding of the culturally responsive computing curriculum.

Theatre of the Oppressed

In the early 1970s, Augusto Boal created the art form known as the Theatre of the Oppressed (TO).. Prompted by the injustices in his home country of Brazil, Boal (1985) developed body techniques to facilitate rehearsals to resolve conflicts rooted in social issues. Techniques like forum theatre, a form of participatory theatre through collaborative movement with the body, helps expose the structural inequities within a system to explore equitable outcomes. Participant engagement in the TO exercises, specifically image theatre, included individual representations of socially embedded STEM terms, such as power. The reflexivity involved in these exercises sparked dialogue among participants about the diverse representations and meanings that they associated with concepts of power. These discussions laid the groundwork for relationship-building and the development of critical consciousness.

Data Source and Sample

The qualitative data used for this study come from year three of a larger study, Fall 2022 cohort of mentor teacher (MT) interviews on their culturally relevant professional development (CRPD) experiences. Years one and two of the study occurred at the height of the Covid-19 pandemic; therefore, changing the implementation of the program from in-person to virtual made those two years pilot studies. The semi-structured interviews were virtual and took place the week following the last Saturday camp in October 2022. The nine interview questions assessed the MTs' CRPD experience becoming facilitators at the culturally responsive cybersecurity camp. All MTs consented to participate in the study, totaling 10 participants for the semi-structured interviews audio and video recorded using Zoom. The data collection process for the TO exercises involved a combination of researcher field notes and interview questions. For example, during the CRPD, MTs were given prompts to perform image theatre. The researcher took field notes on the MTs' products, including their explanations, feelings, observations, and reactions to other MTs' images. In addition, the responses provided in the chat on MT observations and reactions to other MT participants were also added to the data

Research Question	Interview Question	Sub-Theme	Select Quotes
RQ1: How do mentor teachers for an informal cybersecurity camp interpret culturally relevant pedagogy?	#1- Before the Cyber Warrior Camp professional development (PD) would you have described yourself as a culturally relevant mentor teacher?	Culturally relevant teaching is a learned behavior.	<i>Yes, I would have, because of my previous experience over the summer.</i> -Rae
	#6 - What has been your experience implementing a culturally responsive computing curriculum?	Student behaviors shape pedagogy.	<i>I was just kind of asking at the end like, "How are you guys feeling, what is enjoyable and what things can I do for the next week?"</i> - Marc
	#7 - Did the PD effectively foster your skills as a culturally relevant teacher? Can mentor teachers learn to be competent culturally relevant teachers from three 2-hour session PDs?	Defining the purpose for teaching.	<i>Yes, I truly believe I got the support that I needed. Having discussions weekly discussions about what's culturally relevant having discussions about different scenarios. Like I said earlier, speaking of people with different perspectives, it equipped me with the skills to go into the classroom and teach culturally relevant teachings.</i> - Cora
	#9 - Describe how you were prepared to become a mentor teacher for the Cyber Warriors Fall 2022 camp? What kinds of activities/assignments did you complete? What was most helpful about culturally relevant professional development?	Discovering self and others' attributes.	<i>You always felt like everybody had something to say and had something positive to say, and you had something positive to say about it.</i> -Elaine
RQ1 Theme: Interpretation of CRP	Mentoring as the Blueprint for CRP		
Research Question	Interview Question	Sub-Theme	Select Quotes
RQ2: What do mentor teachers' reflections reveal about culturally relevant pedagogy?	#2 - How did the Cyber Warrior Camp PD influence your perceptions of culturally relevant pedagogy?	Normalizing learning and responding to student differences and needs.	<i>I was made more aware of individual aspects of a person. And how this can influence the way in which people see things.</i> - Anne
	#3 - What is your understanding of the difference between traditional forms of pedagogy/teaching and culturally relevant teaching?	Instruction is personalized, relevant, and liberating.	<i>I feel like traditional teaching is kind of a funnel where it takes a broad audience, but kind of has them all create something that's within like a very small window of acceptability.</i> - Anne
	#4 - What is the objective/purpose of culturally relevant teaching?	Affirm identities and remove barriers.	<i>Provide [students] the opportunity to inform you what they care about, and once you get them to open up about that, but help them discover the resources that would help them make a change.</i> - Monique
	#5 - What do you think makes a lesson or a teaching practice culturally relevant?	Student life experiences become the curriculum.	<i>[The] way you pass that information to the student.</i> - Anthony
	#8 - What do you think are the key skills, attributes, and/or characteristics of a culturally relevant teacher?	CR teachers teach to the whole child.	<i>It's being aware that there's more than just the individual that you see in front of you that two-dimensional part that you're looking at.</i> - Marc
RQ 2 Theme: Reflection of CRP	Teachers must be learners, advocators, life coaches, and curriculum writers.		

Table 3. MTs Interview Data

sources. Screenshots of the individual and collective group pose from the image theatre were taken to serve as a data source for the TO work. The purpose of this data collection was to explore the influence on their awareness of inequities in cybersecurity education and the workforce. Member checking of the interview transcript data was conducted by the researcher.

Information on becoming a virtual cybersecurity camp MT was advertised on the DSEC website and newsletters, in emails to STEM departments and graduate programs at universities and community colleges in Arizona and Maryland, and on social media (X, LinkedIn). MT participants in this study were ethnically diverse (see Table 2). However, the distribution of gender was less equal with predominantly female participants (eight vs. two male-identifying). MT applications were reviewed by the research team for experience working with underrepresented youth in informal spaces and involved in efforts to promote social change. Although the camp content was cybersecurity, this did not restrict participants from disciplines other than computer science to serve as MTs: one undergraduate majored in business and another in digital culture. Also, undergraduate and graduate students from 4-year colleges and community colleges, a college professor, industry professional, and K-12 teacher comprised the sample of mentor teachers.

Data Analysis

I employed a thematic analysis approach to the interview transcripts. Thematic analysis is a method of analyzing qualitative data and can be described as the process of identifying, analyzing, and reporting from the data trends (themes) (Braun & Clark, 2006). Following the qualitative research method of attaching meaningful attributes (codes) to interpret the data and identify themes embedded within the content (Saldaña, 2021), I divided the nine interview questions into two groups that answered RQ1 interpretations of CRP and RQ2 reflections on CRP. Using an Excel spreadsheet, a single interview question was written on a sheet with the 10 MT responses, repeating the process for all nine interview questions (Figure 1). The purpose of examining the impact of CRPD through the lens of interpretation and reflection is to (1) test a model for CRPD that underscores the application of each CRP tenet in an informal cybersecurity camp, (2) test knowledge transfer of CRP theory using arts-based methods, and (3) test the perceived purpose of CRP to teach cybersecurity.

From the interview data of each MT, I identified keywords (e.g., relationships, flexible, values). Next, themes were formed through open coding (Saldaña, 2021). Compiling lists of keywords into codes for each interview question formulated a set of sub-themes for RQ1 and a set of sub-themes for RQ2 (see Table 3). In Table 3, data is organized according to the two research questions being investigated. The CRPD intervention was used to explore the understanding of culturally relevant pedagogy

through the lens of “interpretation” and “reflection” by MTs. RQ1 consists of the MT interpretations of CRP, which include the interview prompts, generated sub-themes, and select quotes for RQ1. RQ2 consists of the MT reflections of CRP with the interview prompts, sub-themes, and select quotes for RQ2. While each question approached the same topic from a different perspective, examining them independently fostered a deeper appreciation of the nuanced ways information was processed. I reviewed the four sub-themes for RQ1 and created the main theme; likewise, from the five sub-themes for RQ2, I created a main theme. The quotes selected from the data are intended to provide insight and understanding into the development and formation of the main themes within the analysis.

The process of data analysis using Theatre of the Oppressed techniques is inherently collaborative between the researcher and the participants. This collaborative approach is foundational to the Theatre of the Oppressed methodology, which aims to empower marginalized groups and give voice to diverse perspectives (Boal, 1985). For instance, the construction of poses through image theatre asks the participant to demonstrate with their body what the term or phrase means. The next step involves inviting the audience to interpret what they see or feel from these physical representations. The sharing of interpretations contributes to the research findings and complements other forms of data collection.

Results

An analysis of the data for the impact of culturally relevant professional development (CRPD) on mentor teachers’ interpretation of culturally relevant pedagogy (CRP) and reflections of CRP revealed two major themes. RQ1 Theme was *mentoring as the blueprint for CRP*. RQ2 Theme was *teachers must be learners, advocates, life coaches, and curriculum writers*.

Mentoring as the Blueprint for CRP

Data from the mentor teachers’ interpretations of CRP revealed a shared perspective that learners’ cultural and linguistic background informed how they communicated their understandings and applied STEM content. The realization of mixed student interpretations around STEM topics raised MTs awareness of the value of positioning

themselves as learners to be culturally relevant in their teaching. In hindsight, the 10 MTs assessed their CRP skills according to what they learned from the CRP professional development. Based on the information provided, the results were categorized into three stages. In the majority, five MTs described themselves as already being culturally relevant. They shared examples from their upbringing that they felt had prepared them to be culturally relevant. Cora talked about this in her response:

Yes, I believe I was a culturally relevant mentor teacher beforehand. I feel like my life experience sort of made me more culturally relevant. So, like the school I attended, the demographic of the area.

Four of the MTs considered themselves not at all culturally relevant before having the CRPD experience. Anne, for example, admits, “Probably not because there’s been so much that I have learned over the course of the camp.” Only one MT was undecided on describing themselves as a culturally relevant mentor teacher before the CRPD.

Because culturally relevant and responsive frameworks defined the implementation of the cybersecurity camp, often the MTs referred to personal instances when they needed to be culturally relevant/responsive because of the subject matter and/or student population. As an example, Rae shared the strategies she used during the cybersecurity camp to center the students’ lived experiences as the source of the curriculum: “I had to always, you know, just start the conversation. Maybe call someone’s name, you know. Try to get the conversation running.” Although some MTs confessed to not realizing their teaching style could be identified as CRP, throughout CRP represented an expression of MT values and beliefs about education for students not well represented in STEM. For example, Anthony explained, “You should know how to talk to the student and all that, respect them . . . because everybody is different, and we are in a different generation.” Building relationships with students defined how MTs understood implementing CRP to students that came from cultural backgrounds not familiar to them as part of their responsibilities during the camp.

MTs described learning from others the art of performing in a manner that is culturally relevant. According to Lynda, when describing the takeaways from the CRPD, “I’m definitely learning a lot of tricks and tips

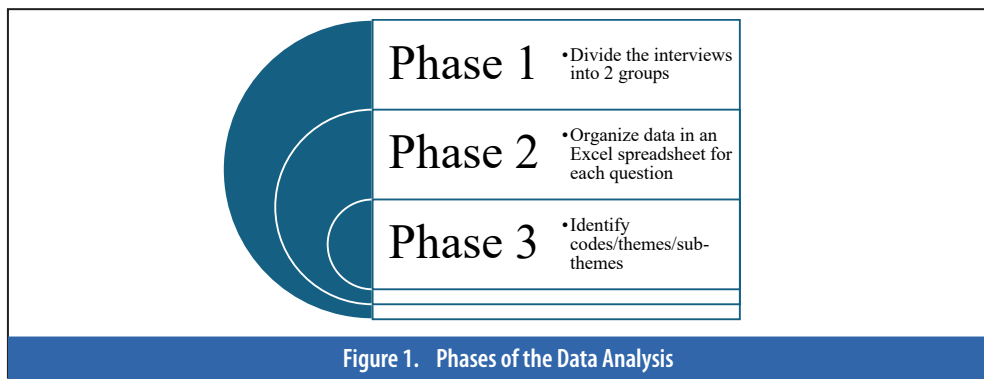


Figure 1. Phases of the Data Analysis

from the team on how to incorporate the relevance of our community and our society, and the way we live." In other instances, MTs expressed how the structure of the professional development helped them do a deep dive into CRP that avoided superficial teaching about the theory. Kena recalls,

The initial sessions . . . explained about what is culturally relevant. And what are those terms and everything . . . What is the meaning of knowing of being a culturally relevant teacher? And what does it mean to be a teacher in general about how a teacher should be.

Before facilitating the cybersecurity camp each week, MTs were given time during the cybersecurity curriculum sessions to practice being culturally relevant and/or culturally responsive in their virtual setting. Lynda, for instance, said this about the preparation: "Everything that you needed to do that following Saturday was discussed, and it was basically like a trial run." The inclusion of interactive experiences that modeled the theory in practice as part of the CRPD design became a support to the MTs. Overall, MTs highlight the significance of mentorship in acquiring the confidence and skills to apply a culturally relevant approach to the teaching of cybersecurity content for a virtual camp.

Teachers Must Be Learners, Advocators, Life Coaches, and Curriculum Writers

Hosting virtual sessions impeded traditional methods of teacher collaboration and the use of space to share ideas. However, introducing an arts-based approach, namely Theatre of the Oppressed exercises, helped conceptualize and operationalize CRP during professional development. When asked to share reflections on CRP, the theme that emerged from the MT data was being change agents by personalizing student learning through relationship building that centered culture. An MT, Elaine, articulated opinions about the role of culture to characterize the objectives of CRP, saying, "Every student has different needs. And, if we're not aware of other cultures, if we're not aware of other differences . . . then we can't successfully support those students." To this point, Anne emphasizes critiquing teaching practices,

If you are on your end, trying the best that you can, but only coming from your culture or your experiences, and not fully understanding that the other person comes with these other experiences as well, it's going to be hard to kind of break that communication barrier, or you might misinterpret something, or they might misinterpret something.

Other MTs' reflections on CRP talked about the limitations of traditional styles of teaching that standardize instruction and uphold dominant norms for defining what knowledge is valued or accepted in STEM education. Attempting to disrupt the cultural omissions of non-dominant groups through CRP in cybersecurity education, Monique said, "I try to apply [cybersecurity content] to everybody, regardless of your race, gender,

age, physical ability." However, apparent through notable curricular adjustments to the cybersecurity lesson were MT agendas to avoid exclusionary teaching practices. The origins of such beliefs were evident in Rae's conclusions on teaching styles being opposite of teaching practices in most classrooms because, the "CRP method is more geared towards understanding each student's goal for the class."

Repeatedly, MTs described examples of marginalized student groups as counter to culturally relevant practices. Take Marc's example of what makes a lesson culturally relevant:

So not necessarily saying like this is the right answer but being able to communicate. Here's the answer, as we know it. But what are some other variables that could exist based around understanding?

Doing the work of tailoring the academic and social environment to nurture learners from majority marginalized communities using CRP meant for most MTs assuming the role of a life coach. In keeping with the Cyber Warrior camp purpose to address the talent gap by race, ethnicity, gender, and language in STEM education, MT reflections of CRP revealed objectives to equip the learners to disrupt inequities. According to Lynda, CRP should serve to:

. . . prepare the next generation and to implement a change, because there's things about our society that we don't like, and the best way to implement change is to first get the knowledge and then create a plan and to keep everyone aware so that things could go differently.

Woven throughout the MTs' reflections of the CRP theme was advocating for race and gender equity during the cybersecurity camp. Culturally relevant teaching for Ada involved recognizing the opportunities afforded in the lesson to integrate social issues with cybersecurity content:

So, one, we're challenging them to think critically about themselves and about society ideally. And then they're also like sharing perspectives with each other and understanding each other's perspectives.

Observations of MTs raised awareness of race and gender inequities in cybersecurity education, encouraging them to pay attention to the barriers that hinder access. For Marc, the process begins with

. . . being culturally informed, right, or at least being receptive to understanding the differences that could exist. I think, maybe also taking in a certain level of reactivity as opposed to authority.

The MTs had specific ideas on what attributes a culturally relevant teacher needed. A common theme was taking an individualistic approach to teaching, while some MTs focused on teacher behavior and attitudes towards the learner. Monique's statement poignantly summarizes the shared opinions on what culturally relevant teaching skills are needed: "If you are patient with them, they may

ultimately allow you to come in and guide. Then open minded about others, you know. And then, being respectful. Those are the three most important attributes to me." In hindsight, MTs revealed how the CRPD influenced them to consider methods of engaging campers in recognizing the relevance of cybersecurity content as a tool to improve the social norms and recreate new equitable structures in STEM education and the workforce.

Discussion

Broadening participation by gender, ethnicity, and race in STEM education or workforce through informal STEM camps must include teacher preparation in culturally relevant practices. However, it tends to be the norm that STEM initiatives bolster diversity along gender and/or race/ethnicity without contextualizing the pedagogical and curricula barriers fueling non-dominant groups' inability to learn and thrive in the field. Instead, teachers of informal STEM camps are given the responsibility to promote student interest, content mastery, retention, and success without formal preparation to achieve this goal. It is almost assumed teachers for informal STEM camps instinctively know how to address the complexities of underrepresentation in STEM by gender and race/ethnicity and other underrepresented identities, likewise, have competencies to teach culturally and linguistically diverse learners. As such, turning a focus to informal STEM teacher preparation in CRP is necessary given the demand for gender and racial/ethnic diversity in STEM fields for transformative outcomes.

To implement CRP in STEM, you must be curious about the students' lived experiences, cultural backgrounds, and STEM identities. STEM teachers who employ CRP have a philosophy of teaching that is culturally appropriate and rejects dominant practices of cultural blindness. Cultural blindness, according to the American Psychology Association, reflects an individual's "inability to understand how particular matters might be viewed by people of a different culture because of a rigid adherence to one's own culture" (Drew, 2022, p. 1). Few studies in education investigate the impact of cultural blindness on teaching and learning for racially/ethnically diverse students (Welton et al., 2015). For example, a study on technoscientific traditions (Cocq, 2022) examines the integration of digital humanities with indigenous knowledge when harvesting, categorizing, and sharing data. To illustrate the importance of centering perspectives of groups often marginalized, specifically Indigenous peoples, the study highlights the influence of culture on technology designs and how, when not critiqued, they perpetuate exclusionary practices. Anwar (2019) noted the need for a strategy to address widespread cultural blindness when it is not something measured or discussed in formal education; this makes the case for STEM teacher preparation in CRP. This way, CRP's focus on student

sociopolitical or critical consciousness development will help raise awareness of inequities in STEM education and beyond from practices such as unacknowledged cultural blindness.

Cultural and racial/ethnic blindness encourages racism in STEM education. Culture is the DNA of a society, “thus humans and culture can not be separated from each other” (Hura, 2020, p. 2). Science scholars problematize the Eurocentric culture of science education and research the interconnectedness of race/racism to the inequitable outcomes in science teaching and learning for people of color (Mensah & Jackson, 2018; Mutegi, 2011; Sheth, 2019). For example, Moore’s (2008) research on teacher preparedness for urban elementary science classrooms examined teachers’ cultural biases toward diverse students. Such examples expose the consequences of biased attitudes about different cultures that hinder equitable teaching practices. Despite US societies being multicultural, STEM teacher preparation, as culturally competent for people of color and/or non-native English speakers, has not reached the systemic level. Not emphasizing the individual and social components of culture informing STEM curriculum and pedagogy maintains traditions of cultural blindness, cultural bias, and cultural racism (Bryan & Atwater, 2002; Lee et al., 2020; Moore, 2008; Morton, 2022; Sheth, 2019). The work of Madkins and Morton’s (2021) study with elementary teacher candidates to disrupt the perpetuation of anti-blackness in STEM education as a social justice initiative, however, offers an approach to redefining STEM culture. Likewise, Moore’s (2008) case for CRP in science education reinforces the centrality of culture as facilitating the competencies needed to enact science education for all.

The findings suggest how the use of critical arts-based methods for STEM teacher professional development in CRP encourages equitable teaching. STEM teacher implementation of the CRP theory requires methods that involve interactive experiences, such as the Theatre of the Oppressed, over multiple 2-hour PD sessions. Therefore, it is recommended to incorporate Theatre of the Oppressed as a framework to introduce CRP to STEM teachers. Because CRP is grounded in the valuing and centering of the individual, hence their culture, this creates an acceptance for multicultural perspectives. Therefore, the use of CRP tenets is recommended to design STEM teacher professional development to cultivate equitable teaching practices.

Limitations

The study explored MT experiences in CRPD. However, delving deeper into the culturally responsive practices employed by the MTs could have provided more profound insights into the influence of the CRPD. An aim of the cybersecurity camp was to implement a culturally responsive computing curriculum to promote equitable teaching outcomes in cybersecurity. The MTs pedagogical style played a key role in creating a culturally

responsive learning environment. MT observations while teaching the cybersecurity curriculum might help to identify effective methods and supports for fostering culturally relevant/responsive practices for virtual cybersecurity camps. Therefore, this CRPD study may have benefited from knowing precisely what pedagogical techniques and practices the MTs used to translate CRP theory into practice. Future studies in which the MTs participate in CRPD for facilitating a cybersecurity camp might include observation protocols that investigate teacher CRP applications during cybersecurity camps. Another limitation may have been not conducting focus groups with the MTs. Rather than relying solely on semi-structured MT interviews to capture their CRPD experience, a focus group setting might have added further nuance to the data from participants being able to hear and respond to each other’s experiences. Future studies might include MT focus groups.

Conclusion

This qualitative study reports on how mentor teachers (MTs) participating in culturally relevant professional development (CRPD) for an informal cybersecurity virtual camp interpret and reflect on culturally relevant pedagogy (CRP) to advance equity in STEM education. Facilitators are an integral part of informal STEM camps seeking to expose and provide access to systematically excluded learners; however, preparing them to assimilate and cope with inequitable structures becomes the default with teaching strategies that solely emphasize content mastery. MTs demonstrated how the multiple and comprehensive CRPD sessions impacted their interpretation of CRP over time from being elusive to having a concrete understanding on how to implement the CRP theory. Likewise, reflections after the CRPD on CRP illustrate MTs’ movement toward developing a CRP mindset. Although growth occurred in how MTs interpreted and reflected on the theory of CRP, ongoing research will continue to determine length of time and resources needed to cultivate a CRP mindset.

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