Impact of Culturally Relevant Pedagogy on Black Learners Enrolled in Online Undergraduate Mathematics Classes

Dr. Lauren Hennings
Department of Learning and Instruction, Graduate School of Education, University at Buffalo, The State University of New York Buffalo, NY 14260, USA

Dr. Alexandra Schindel
Department of Learning and Instruction, Graduate School of Education, University at Buffalo, The State University of New York Buffalo, NY 14260, USA

Abstract
Scholars have often proposed the use of *Culturally Relevant Pedagogy* (CRP) as a way to improve the experience of Black learners in mathematics classrooms. Prior research shows Black learners show improvement in comprehension, engagement, motivation, and confidence as a result of CRP's use. However, there is limited research on whether Black learners respond similarly when exposed to CRP in undergraduate online learning environments. This qualitative teacher-researcher case study examines learners' experiences in an online undergraduate algebra course to explore CRP's pedagogical design in an online mathematics environment and its impact on three Black learners' engagement, motivation, and confidence. Results show that as a result of the use of culturally relevant problems as part of the online course, specifically in weekly discussion boards and written reflection assignments, participants showed improved engagement, confidence, and motivation towards learning mathematics.

Keywords: Black learners, online learning, undergraduate math, culturally relevant pedagogy, engagement, motivation

Hennings, L. & Schindel, A. (2025). Impact of culturally relevant pedagogy on Black learners enrolled in online undergraduate mathematics classes. *Online Learning, 29*(2), pp. 357–392. https://doi.org/10.24059/olj.v29i2.4453

One of the most significant needs in US schools today lies in increasing achievement among Black students in mathematics. In 2015, only 7% of Black twelfth graders were at or above proficient level in mathematics, while White Americans were at 32% and Asians at 47% (National Center for Education Statistics, 2015). Black learners have also historically been excluded from and underrepresented in mathematics and STEM-based careers. While accounting for 12% of the American population, Black workers only hold 5% of STEM jobs (Milner, 2016). Mathematics acts as a gateway to STEM fields and can be linked to economic success since STEM graduates can access prestigious and lucrative careers (Adelman, 2006; Anderson & Kim, 2006) and since many high-paying jobs exist in STEM fields (Masterson, 2021).

While knowing achievement gaps exist is important, this measure should not be the sole reason for reforming mathematics education. Research concerned with increasing success in mathematics among Black learners frequently attends to their learning experiences and environments. Research shows that Black learners are more likely than their White counterparts to encounter low academic expectations, implicit bias of mathematics ability, negative stereotyping, and less access to rigorous and advanced mathematics coursework (McMillian, 2003; Minor, 2014; Morton & Riegle-Crumb, 2020). However, Black learners bring significant assets and identities to their mathematics learning which they harness as capable mathematics knowers and doers. A significant body of research demonstrates that rigorous and culturally sustaining pedagogies in mathematics can support Black learners by helping improve students' confidence, engagement, understanding, and overall attitudes toward learning (Corp, 2017; Hubert, 2014; Nasir, 2000).

Asset-based pedagogies can improve outcomes for Black learners in mathematics (Battey & Neal, 2018; Bonner & Adams, 2012). One such pedagogy is Culturally Relevant Pedagogy (CRP)—a method of teaching that empowers students intellectually, emotionally, socially, and politically by using cultural references to influence knowledge, skills, and attitudes (Ladson-Billings, 2009). While the use of CRP within in-person mathematics is growing and demonstrating success for historically marginalized learners (Hubert, 2014; Corp, 2017; Nasir, 2000; Fulton, 2009), more research is needed on CRP's role within online learning environments (McLoughlin, 2001).

This research explores the impact of CRP on Black learners in an online undergraduate algebra course. The following research questions guide this study: (1) How does an instructor design and implement CRP for Black undergraduate learners in an online mathematics classroom? (2) What is the impact of CRP on Black learners' engagement, motivation, and confidence? Findings describe the instructor's design of CRP mathematics problems that referenced various features of students' personal lives and addressed critical concerns, such as racial disparities in wealth, homeownership, criminal justice. Black students' interest, engagement, motivation, and confidence were positively impacted by CRP mathematics in online learning.

In what follows, we describe the theoretical frameworks and review relevant literature, including CRP in math classrooms and CRP in online learning. Following a description of the research methods, the results are outlined by first discussing the design of the culturally relevant problems and then the students' responses and reactions to the problems presented. The

discussion problematizes key theoretical and practical issues and implications related to CRP in online mathematics that this study's findings reveal.

Theoretical Framework

Culturally Relevant Pedagogy in Mathematics

Ladson-Billings' Culturally Relevant Pedagogy (CRP) proposes a type of pedagogy that encourages students to maintain cultural integrity while challenging the system of oppression (Ladson-Billings, 1995; Ladson-Billings, 2009). The three components of CRP are academic achievement, cultural competence, and sociopolitical consciousness (Ladson-Billings, 1995). Academic achievement extends beyond test scores to include a variety of types of student achievement, such as being able to solve problems at all levels of sophistication, asking questions, and peer reviewing problem solutions (Ladson-Billings, 1995). Further, CRP instruction must bridge the gap between what students have or should have learned in prior grade levels to what they are currently required to learn (Laughter & Adams, 2012).

In speaking about the importance of the second element, cultural competence, Ladson-Billings (1995) stresses the need to design a learning environment where success in the classroom is compatible with learners' identities. Culturally competent instructors should engage themselves in the communities of the students being taught and be open to learning from those communities to influence their teaching practices (Irizarry & Antrop-Gonzalez, 2007). Thus, this facet of CRP encourages instructors to cultivate strong relationships with students and their communities to fluidly integrate culturally responsive and community-specific information and contexts into instruction. For example, mathematics instructors can utilize their students' favorite music/artists or foods to design a problem involving fractions or ratios to determine how much of a certain ingredient they would need to serve their favorite dish to a certain number of people or use an exponential formula to determine the frequency of the highest note in their favorite singer's vocal range.

The third component of CRP, sociopolitical consciousness, assists students in challenging the status quo by developing critical understanding of unjust systems and using their learning to challenge oppressive systems. However, sociopolitical consciousness is often underrepresented in CRP teaching, including within mathematics (Morrison et al., 2008, Thomas & Berry, 2019). In the context of teaching mathematics, sociopolitical consciousness can be developed as learners utilize mathematical concepts to further understand and reflect upon inequities, such as utilizing statistics to examine racial profiling (Hubert, 2014; Langlie, 2008).

For the context of this research, the researchers utilized CRP as the theoretical framing in the development of instructional design.

This research is also informed by theories of critical caring since the care perspective that teachers take within their work represents a foundational underpinning of CRP. Gilligan (1982), a pioneer of care theory, defines an "ethic of care" as the following vision.

> The self and the other will be treated as of equal worth, that despite differences in power, things will be fair; the vision that everyone will be responded to and included, that no one will be left alone or hurt. (Gilligan, 1982, p. 63)

Noddings' (1984) work on the ethics of care describes how caring relationships between students and educators are only valid if learners believe and confirm educators care for them. Although Noddings (2002) contends the concept of care does not apply universally or similarly for all students in all situations, care theories have paid minimal attention to the intersection of cultural relevance and care. Care theories often leave out the context of caring for Black learners and the contributions Black educators bring to the field of care (Roberts, 2010). These principles align with CRP but emphasize the need for instructors to develop critically caring perspectives within their practice. Thus, Culturally Relevant Critical Teacher Care (CRCTC) aligns with our research on CRP and assists us in articulating our roles as teacher-researchers exploring our practice and the many facets of our students' experiences.

Literature Review

In what follows we review relevant literature to CRP. This includes research that aligns qualitatively with CRP and its facets, and other similar frameworks such as Culturally Responsive Teaching (CRT), and social justice education. Note that while CRP and CRT have differences—CRP centers on attitudes and dispositions, while CRT focuses on competency and practice (Aronson & Laughter, 2016)—they also share similarities. They both embrace social justice in the classroom and viewing cultural differences as an asset.

Our literature review highlights relevant empirical research that studies the use of either of the two pedagogical practices (CRP and CRT) in traditional K-12 in-person mathematics classrooms. To examine more thoroughly what it means to facilitate the under-studied facet of sociopolitical consciousness in math classrooms, we dedicate a separate section below to highlight literature that specifically falls under the framework of Critical Mathematics (CM) or Teaching Mathematics for Social Justice (TMSJ). Empirical studies on CRP in online learning and college math is limited but relevant and will also be highlighted.

CRP and CRT in K-12 Math Classrooms

The body of research reviewed below reveals findings from implementation and outcomes in research featuring CRP and CRT in K-12 math classrooms.

How Do Teachers Implement CRP and CRT?

Studies suggest instructors who successfully implement CRT and CRP are highly knowledgeable of math content and emphasize the connection between mathematics and everyday life. Researchers have provided in-depth examples of what this looks like in practice. Corp (2017) utilized storytelling, via the use of quality African-American literature with realistic or historical context, followed by assignments prompting mathematical reasoning to address issues referenced in the literature. As an example, *Lucky Beans,* a story about a family living during the Great Depression and who had to eat canned beans every night, was used to introduce an exercise prompting students to use mathematical reasoning to estimate how many beans were

in a can. Hubert (2014) integrated sociopolitical consciousness by developing activities requiring students to use quadratic and exponential equations to tackle major societal issues impacting their own communities, such as HIV and teen pregnancy. Successful culturally relevant instructors of Black and Hispanic high-school students try to demystify mathematics by reducing the use of abstract terms and putting more emphasis on real world applications (Langlie, 2008). As these examples demonstrate, culturally relevant topics vary but are attuned to the lives, interests, and critical topics in students' lives. Consequently, due to the unique nature of culturally relevant problems, teachers utilize open-ended questioning as opposed to routine, pre-defined problems (Tate, 1995).

Culturally relevant mathematics teaching frequently emphasizes teachers' having an awareness of the underlying mathematical presence already existing within students' cultures. Researchers emphasize that students' first language is the foundation and can be used to promote empowerment and biculturalism (Gutstein et al., 1997). For example, in efforts to utilize CRP to develop a mathematics curriculum in Ichishkíin, an Indigenous language, instructors took an active approach to discover where fractions reside in Yakama culture. The calculation of fractional geometric measurements, for example, was required for Yakama women who had to build conical homes and tipis without the use of written patterns (Ruef et al., 2020). Notably, the concept of factoring has been linked to the role of kinship and family that is revered in Black culture in efforts to contribute to the development of students' math identity (Bonner, 2014).

Successful culturally relevant teachers form relationships, use connections as foundations of curriculum building, believe in student capabilities, and act as "warm demanders" of academic excellence (Milner, 2016; Berry & McClain, 2009; King-Miller, 2015). Empirical research provides insight into what constitutes critical caring relationships and can be broken into three major findings: (1) Educators show an awareness in how race plays a role in their students' lives; (2) have high expectations; and (3) build interpersonal bonds with students. We make specific note of research aligned with our study's focus on Black learners in mathematics. Educators who successfully implement care into their CRP practice expect greatness (Hambacher, 2018; Hambacher & Bondy, 2016; Ware, 2006) and prepare Black students for the reality of often having to work twice as hard as their White peers to become successful (Jones, 1982). Further, successful Black teachers of Black learners engage in political clarity discussions with their students by acknowledging race plays a role in the realities Black learners experience in their everyday lives, unmasking the overt and covert faces of racism (Collins, 1991; Roberts, 2010; Hambacher & Bondy, 2016, Acosta, 2013). Taking time out to get to know students instead of jumping right into teaching the curriculum, as well as letting them get to know their teachers, demonstrates care to students and makes them more comfortable (Hambacher, 2018, Watson, Sealey-Ruiz, & Jackson, 2016). CRCTC may also include the practice of "othermothering" (or "otherfathering"), expressing parental care in addressing the psychoeducational needs of students (Hambacher, 2018). Students exposed to empathetic care express a sense of connectedness that helps foster students' perceived value and relevance of math (Maloney & Matthews, 2020).

In summary, successful implementation of CRP in mathematics is fostered through teachers' development of authentic caring relationships in which they integrate math learning with students' rich cultural, historical, and political backgrounds. However, all of the research

explored in this section occurred within in-person learning environments, leaving open the exploration of implementation in online settings.

What Are the Results of Culturally Relevant Mathematics?

Empirical research tells us CRP and/or CRT practices in K-12 math classrooms help improve student engagement, confidence, and overall attitudes towards learning the subject. CRT positively correlated to elementary school students' engagement and enjoyment (Corp, 2017). Black secondary school learners showed an increase in confidence and motivation levels towards learning math (Hubert, 2014). Middle school Latinx youth participating in culturally responsive math afterschool programs felt more connected to their peers and staff and promoted engagement (Yu et al., 2021).

In addition to the promising results in student attitudes towards learning, empirical research shows CRP and/or CRT approaches help bridge the connection between math learned in school and math utilized outside of the classroom, or everyday mathematics. The mathematics students use outside the classroom may not be reflected in the curricula they are exposed to in school. The everyday cultural use of mathematics by Black students in particular, such as through shopping in local markets and engaging in sports, can and should be used to build connections to mathematics learned in classrooms (Nasir, 2000; Taylor, 2009).

Curricular reforms that connect content learned in the classroom to everyday math improve students' understanding of the subject and enhance mathematical reasoning (Yu et al., 2021; Fulton, 2009). Urban high school students required to complete a culturally relevant statistics project not only exhibited improved statistical reasoning but were also able to make claims about inequities based on quantitative evidence (Enyedy & Mukhopadhyay, 2007). Schema instruction combined with culturally and linguistically responsive practices improved the skill of solving math word problems for elementary school English language learners (Driver & Powell, 2017). Culturally and linguistically responsive instruction contributes positively to student mathematics performance overall (Driver & Powell, 2017; Matthews & López, 2018).

CRT strengthens students' sense of becoming successful mathematical thinkers (Fulton, 2009). In addition, empirical research demonstrates learners become empowered to achieve mathematics excellence (Gutiérrez, 2013).

Critical Mathematics

Critical scholars in mathematics education argue for curricular changes that allow learners to leverage mathematics learning to understand and analyze injustices and to propose mathematical solutions to them (Frankenstein, 1989; Gutstein, 2006). In his work on Teaching Mathematics for Social Justice (TMSJ), Gutstein (2016) emphasizes that students must learn to *read* the world through mathematics, and consequently develop sociopolitical consciousness, while also *writing* the world, or using that knowledge to better shape society. Students are encouraged to situate themselves in the context of problems and are prompted to figure out how to use math to challenge the status quo and take action against injustices (Harper, 2019; Gutstein, 2003; Kokka, 2019; Gutstein & Peterson, 2005; Gregson, 2013).

Scholarship in the field of TMSJ highlights learners' increased engagement in deep discussions and the substantial use of mathematics in analyzing social justice issues. TMSJ also encourages learners to go beyond the use of straightforward procedures and calculations. Problem-solving typically involves data collection and analysis, substantial math work, and proposing solutions to societal issues. Students play a major role in deriving the mathematical content needed to tackle such issues and are better able to navigate through advanced mathematics (Harper, 2019).

Various curricular examples highlight ways to integrate sociopolitical awareness into mathematics. For example, activities centering on issues such as wealth distribution and income inequality (Gutstein, 2003), living on minimum wage and gentrification (Kokka, 2019), police brutality (Gutstein & Peterson, 2005), and youth criminalization (Gregson, 2013) elicit students' understanding of the world and its inequities through the use of math.

Overall, empirical research shows critical approaches to mathematics learning fosters engagement and helps nurture learners' complex problem-solving skills that are required to tackle pertinent societal issues that impact their communities.

CRP in College Mathematics

Unsurprisingly, the empirical research that focuses on CRP in college math courses tends to have similar characteristics as seen in pre-collegiate levels (Greer et al., 2009; Downing & McCoy, 2021; Jett, 2013; Yull, 2013). However, CRP-influenced reforms within college STEM departments often include encouraging collaboration among students (Johnson & Elliott, 2020). For example, collaborative and community learning is encouraged through mixed ability grouping that supports students who may be struggling (Yull, 2013). Finally, one of the first examples of critical mathematics was articulated in college mathematics learning environments (Frankenstein, 1989).

CRP in Online Learning

When it comes to learning math online, students find it more challenging due to lack of social support and their sense of isolation. Students who already struggle in courses where algebra is taught, for instance, may experience more difficulties if enrolled in an online course (Kim, Park, & Cozart, 2014). While students are at risk of underperforming in an online classroom compared to the in-person environment, for Black learners the performance gap is wider (Xu & Smith, 2014). While these issues exist, one study shows an African-American male still seeing a benefit to online learning due to less pressure of having to conform to white cultural norms that may be present in in-person classrooms (Corey & Bower, 2005). Nevertheless, it is not enough to just throw students into an online classroom and expect everything will turn out for the best. Something must be done to address these concerns.

While there are very few examples of empirical research focusing on CRP online learning in the mathematics classroom, there are works that provide insight into how CRP operates in online settings regardless of subject. Online faculty who are properly trained, engage, and understand the importance of CRP are an asset to teaching diverse learners (Heitner & Jennings, 2016). While these works show similar characteristics found in research focusing on in

in-person classrooms, culturally responsive teaching in online settings also includes providing feedback frequently (Smith & Ayers, 2006) and result in students responding positively to group work activities (Smith & Ayers, 2006; Majewski & Vereen, 2021). Studies also stress the need for instructors to take advantage of collaborative learning activities and varied resources needed to facilitate student interaction (Kumi-Yeboah & Amponsah, 2023). Practices also include asking students to complete a preliminary course assessment to gauge current student ability to engage with technology required for online learning, allowing students to use multiple methods to create and submit reflection assignments, such as audio or video, blogs, or just simple Microsoft Word submissions, letting students facilitate online discussions, and providing students with the opportunity to co-design the course (Woodley et al., 2017).

Purpose

Our review of the literature reveals that little is known about the integration of CRP in undergraduate online math classrooms, and its effectiveness on Black learners remains relatively elusive. Research using non-quantitative measures of learning to examine the effectiveness of CRP on learners is robust, especially when the focus is on student engagement and confidence. However, aside from Hubert's (2014) study, there is limited focus on motivation. Further, Aronson and Laughter's (2016) synthesis of culturally relevant research noted that CRP's positive impact on student motivation was explicitly mentioned when discussing CRP in science and ELA education, but not in the field of math education. Our study addresses the need for additional research in CRP in online mathematics settings while attending to the under-researched areas of instructor care, sociopolitical consciousness, and learners' motivation.

Methods

Methodological Approach and Positionality

The researchers identified that a qualitative teacher-researcher case study approach was well-suited to address the research questions exploring the design, implementation, and impact of CRP on Black undergraduate learners in a seven-week online Algebra course. Case studies are often used to document reaction, attitudes, and behaviors of the participants in response to a particular event (Saldaña & Omasta, 2018). Cochran-Smith and Lytle (2009) define practitioner research as forms of inquiry where the practitioner is also a researcher who aims to improve students' learning experiences through continuous engagement of inquiry. Research is typically conducted by insiders, i.e. the practitioners, using their own site (classes, schools, districts) (Anderson, Herr, & Nihlen, 2007). Practitioner research requires having a great deal of knowledge of the educational contexts and/or situations one works or participates in (Cochran-Smith & Lytle, 2009, p. 42). This form of research, McKernan (2021) asserts, is based on three assumptions: (1) Naturalistic settings are best studied by those experiencing the problem, (2) naturalistic settings influence behavior and (3) qualitative inquiry is best suited for examining naturalistic settings.

As authors, we are a Black woman (Lauren) and a white woman (Alexa). For this manuscript, Lauren acted as the principal investigator and practitioner researcher, and Alexa

contributed content expertise in developing the manuscript. The first author (Lauren) taught the online undergraduate math course in this study for three years prior to the research. Lauren's positionality as a Black female is important in this study in which the academic excellence, cultural competence, and political awareness of Black learners is explored because the shared racial and cultural identity provides them with some aspects of shared knowledge and experience. Lauren has also been a student in online classes and shares the experience of being one of only a few Black students in an online learning platform. This positionality made her conscientious of the classroom social situations of student participants.

Course Context and Procedures

The study context is a seven-and-a-half-week *College Mathematics* course designed to help students develop quantitative literacy skills for their personal and professional lives. Students use reasoning and mathematical methods to find solutions to real-world problems and use algebraic, financial, proportional, probabilistic, and statistical methods to draw conclusions and/or make decisions. Students were required to complete online homework and quizzes administered through an online tutoring and assessment program.

For this study, participants were recruited via email prior to the course beginning. The email explained the purpose of the study and included an attached consent form for students to sign. After consenting, participants completed an online introductory survey which asked students about their personal lives, such as, where they are from, their hobbies, and their family life, as well as about their prior math experiences in school, particularly surrounding algebra, their perceived mathematical ability, and the relationship between sociopolitical issues and mathematics. The survey was designed to mitigate instructor stereotyping and to personalize the design of culturally relevant mathematics problems. For example, in Jaylen's introductory survey responses, she said she saw a connection between math and social justice, stating "I believe it can play a role in local thinking. Using statistics and patterns to determine where the issues lie and how can they be corrected." Therefore, designing a problem that referenced statistics and patterns through a graph was warranted.

All students were required to participate in weekly discussion boards by making an initial post and replying to at least three other posts. The instructor replies to each student's initial post with additional mathematical problems. For the students who agreed to be participants in this study, the reply posts consisted of a culturally relevant problem either similar to a problem they got wrong on the homework or a problem that was related to that week's topic of discussion. All students also submit four written assignments reflecting on what they found most important about the week's lesson and the application of their learning in their everyday life or career. Participants were also prompted to complete an optional culturally relevant problem with their reflections.

The course curriculum, homework, discussion board topics, and reflection questions were prescribed by the school, leaving little room for instructors to make changes. Thus, CRP was implemented as an added or secondary component to the standard (prescribed) curriculum. Regardless of whether student participants respond to the culturally relevant problems the instructor posted, students were still required to complete the homework and quizzes the school assigned, which contain what might be considered traditional, non-culturally relevant problems.

Participants

Three female students who identify as Black or African American participated in this study. They will be referred to by the pseudonyms Jaylen, Tiffany, and Candace. Candace identified her proficiency level in algebra as moderate and testified on her struggle with figuring out what next steps to take in a problem. Jaylen said she was really good at algebra but was not too fond of graphing. Tiffany confessed she was "just ok" at algebra but struggled the most with taking tests and memorizing formulas. All three were enrolled in the online *College Mathematics* course Schindel (author one) taught at a private for-profit college that offers associate degrees on all campuses and bachelor's degrees at some campuses. All the students in the study came from the same school and were enrolled in the same course, although different sessions, which constitutes within-case sampling (Saldana & Omasta, 2018).

Data Collection and Sources

Researchers collected data during all phases of the research, which included a lengthy planning phase, implementation phase, and follow-up phase in which participants were interviewed after course completion. To address the first research question regarding the design and implementation of CRP, the data collected included detailed field notes, the designed culturally relevant problems, and instructor feedback responses. The use and collection of field observation notes is similar to other practitioner research (Gutstein, 2013; Martell, 2013). After each week in the course, the researcher audio-recorded field notes to provide a detailed reflection of what occurred during that week, including the students' engagement and performance in the class, and the use and design of culturally relevant problems. I (Lauren) also reflected on my own positionality in field notes, examining my views of the sociopolitical issues in problems and how my own experience as a STEM student and worker contribute to how I designed problems and my interaction with the participants.

To assess the impact of CRP on the learners (RQ2), the following forms of data were collected during this study: answers and explanations to the culturally relevant problems assigned in the discussion boards and reflection tasks, more observation field notes, and end-of-course interview responses. After the course ended, participants participated in a one-on-one audio recorded interview focused on participants' perceived level of engagement, motivation, and confidence, their thoughts on how to use math to address a posed societal issue, and their experience using math outside the classroom. Interviews also explored participants' responses to the culturally relevant problems posted. All participants were asked to assess their performance in the class and to evaluate their experience.

Data Analysis

All data collected were transcribed and then analyzed using the data analysis software Dedoose©. To answer the first research question, an initial first phase of data analysis was conducted and consisted of deductive coding the designed culturally relevant problems using preset codes. The deductive codes initially used were the three facets of CRP: cultural competence, sociopolitical consciousness, and academic excellence. The data were then further analyzed utilizing inductive coding to explore the ways in which each element of CRP evolved within the research. I used Dedoose software to figure out if there were any common themes or trends present that would help define features of the culturally relevant problems used. The

software helped list the common descriptive codes present in excerpts that were deductively coded. For example, below is the analysis from Dedoose showing how often certain inductive codes appeared alongside the parent deductive code “Academic Excellence”, i.e. the common themes that showed up in culturally relevant problems that demonstrate this one-third component of CRP.

Figure 1

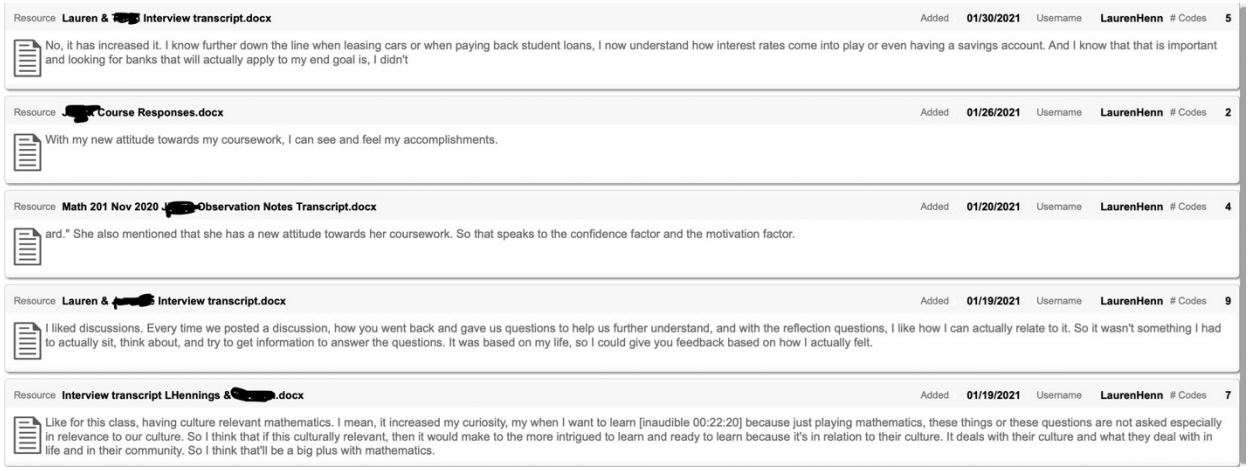
Codes	Academic Excellence	Graphs	More Guidance Provided	More practice	New Technology	Totals
Academic Excellence		2	27	9	6	44
Graphs	2		2			4
More Guidance Provided	27	2		3	2	34
More practice	9		3			12
New Technology	6		2			8
Totals	44	4	34	12	8	

The field observation notes collected were coded using descriptive coding. The instructor feedback was also analyzed using inductive and descriptive coding in efforts to discover common themes present in the interaction between the practitioner-researcher and student participant.

To answer the second research question, a combination of in vivo and emotion coding was applied to the one-on-one interview transcripts. In vivo coding uses the interviewee’s own language to derive codes (Saldana & Omasta, 2018). For example, excerpts were coded as “relatable” when students explicitly said the problems were more relatable to them. The emotion coding used applied labels to “the emotional states experienced or recalled by the participant, or inferred by the researcher about the participant” (Saldana & Omasta, 2018, pg. 130). These methods were useful in discerning instances when students indicated they felt confident, engaged, and/or motivated towards learning, with or without them explicitly stating so. For instance, if a student expressed they were comfortable doing a problem, that excerpt would be coded as “confidence,” The following examples are excerpts from all three student interviews that were coded as “motivation” based on the participants’ responses.

Figure 2

Student Interview Excerpts Coded as "Motivation"



Inductive and descriptive coding were applied to the student answers to the culturally relevant problems and to the rest of the field observation notes. The coding applied on the student answers and field observation notes was used to determine in what ways instances of high engagement showed up in problem solving. Below is a summary of all data sources, their purpose, and how they were coded.

Figure 3

Summary List of Data Sources

Phase	Data Source	Description	Coding
Planning	Introductory Survey Responses	Responses collected from students prior to beginning of course. Used to get to know students on a more personal level. Asks about hobbies, life outside of school, prior experience with math, etc… Information used to design individualized culturally relevant problems.	N/A
Implementation	Culturally Relevant Problems	Designed using info from introductory surveys. Assigned in discussion board reply posts and reflection assignments throughout duration of study. Data used to develop common themes exhibiting how three tenets of CRP show up in problem design.	Deductive coding using one of three codes : "cultural competence", "academic excellence" or "sociopolitical consciousness". Later applied descriptive coding.
	Students' Answers to Problems	Data used to gauge levels of engagement exhibited by students during problem solving.	Inductive and descriptive coding.
	Instructor Feedback	Data used to determine nature of feedback exhibited from instructor in a culturally relevant online environment.	Inductive and descriptive coding.
	Field Observation Notes	Recorded and documented to reflect instructor's thoughts and mindset during implementation process. What was instructor thinking? Why did the instructor design the problems the way she did? How did instructor view students' responses to problems? What did instructor want to convey during problem design and while providing feedback? Etc...	Inductive and descriptive coding.
Follow Up	One-on-One Zoom Interviews	Data collected from student participants at the end of course, after grades were submitted. Provided forum for students to reflect on their experience during the study. Data used to determine how students viewed their own levels of engagement, motivation, and confidence as a result of CRP problems.	Emotion, amd in-vivo coding

Teaching CRP in Online College Mathematics

In this section, we describe how Lauren integrated and implemented CRP into an online college mathematics classroom to cater to Black learners. I provide examples and excerpts of problems for each of the three components of CRP and I share my reasoning behind the problem design. Lastly, I discuss the feedback I provide to students and how the nature of the feedback sought to contribute to a culturally relevant environment.

While the three facets of CRP are discussed separately below, they were in fact integrated within the problems I designed. Problems exemplifying academic excellence have also encouraged cultural competence, sociopolitical consciousness, or both. One problem, for example, asked a student to think beyond the scope of the course by using technology, specifically a new Excel formula, to analyze the racial gaps we see in student loan debt. In this sense, I encouraged students to learn new tools or higher-level mathematics thinking than that of the original course curriculum. Academic excellence is not compromised when either cultural competence or sociopolitical consciousness is stimulated.

While I did not design problems that explicitly epitomized all three facets of CRP, I would argue that problems inspiring sociopolitical consciousness and academic excellence also embody cultural competence. Church and religion are very important and highly respected elements of Black culture. Cultural practices found in Black churches, such as the nature of call-and-response interaction during service and the prominent use of imagery, have been shown to influence strong activism (Pattillo-McCoy, 1998). Hence, sociopolitical consciousness has also become an innate facet of Black culture. Problems encouraging sociopolitical consciousness can be argued to also show cultural competence since these problems acknowledge and respect an already existing component of Black customs and heritage: Black activism.

Cultural Competence: Hobbies, Student Life, & Current Events

I drew upon the information I learned about and from the students in their survey response to design problems. The problems that were initially deductively coded as promoting *cultural competence* had some reoccurring themes appear during the inductive coding process. These problems often referenced known factors of the student's life, such as their family, their outside-of-school jobs, and their hobbies. There were also instances where current events or trending topics that involved Black Americans were referenced when designing problems.

For example, Jaylen indicated that she loves crafting and shared the names of her siblings. The culturally meaningful mathematical problems I posted for Jaylen in the discussion board and in reflection assignments referenced these factors and were also connected to the content the students were learning, such as proportional reasoning and probability. Below is one example.

> Review the YouTube video for instructions on how to craft and use a fortune teller origami: https://www.youtube.com/watch?v=Mj7WE30zJUk . Assume you and your younger sister <sister's name>, are playing with the origami, with you as the fortune teller (the person holding the origami).

> To play the game, your sister has to pick among the four colors (orange, red, blue, and black). Depending on the color she picks, you make a number of movements (pinches/pushes) equal to the number of letters in the color she picks. Your movement results alternate between showing 1, 2, 5, 6 or 3, 4, 7, 8, with the first movement showing 1, 2, 5, 6. You then ask her to pick one of the four numbers shown.
>
> Now that you know how the game works, calculate the probability of <sister's name> picking orange or blue and then picking an even number or a 3. Explain your reasoning in at least 150 words.

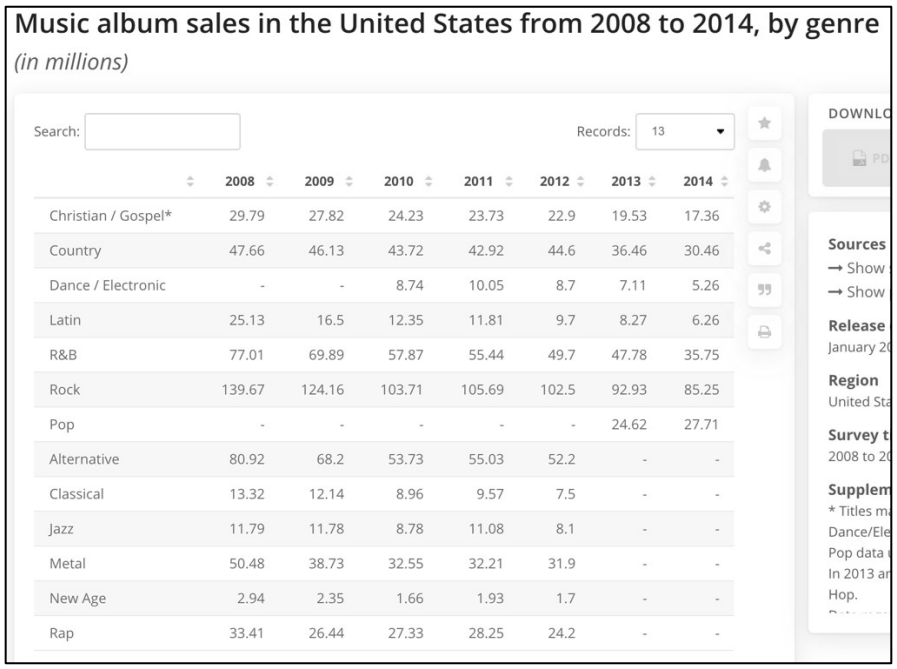
Here, the problem encourages the student to enhance their understanding of probability while also appreciating their love for crafting. In this example, cultural competence is fostered in and through mathematics by demonstrating respect for the students' culture. The problem is aligned with the students' interest and fosters a deeper understanding of the craft by seeing it through a mathematics lens.

In Candace's initial survey, she indicated that she likes to bowl as one of her hobbies, comes from a nine-child family, (seven sisters and a brother), and likes to listen to gospel music. The problems below—two from discussion boards and one from a reflection assignment—were designed for her specifically.

> In a 9-child family, what is the probability of having 1 boy and 8 girls? (Birth order is irrelevant.)
>
> What is the probability of knocking down exactly 5 pins in a frame?
>
> What was the average number of album sales for gospel music from 2008 to 2014? During which year did album sales seem to differ most from the average?

Figure 4

Chart of Data Provided to Candace Along with Assigned Gospel Music Problem Above



Music album sales in the United States from 2008 to 2014, by genre

(in millions)

Search: Records: 13

	2008	2009	2010	2011	2012	2013	2014
Christian / Gospel*	29.79	27.82	24.23	23.73	22.9	19.53	17.36
Country	47.66	46.13	43.72	42.92	44.6	36.46	30.46
Dance / Electronic	-	-	8.74	10.05	8.7	7.11	5.26
Latin	25.13	16.5	12.35	11.81	9.7	8.27	6.26
R&B	77.01	69.89	57.87	55.44	49.7	47.78	35.75
Rock	139.67	124.16	103.71	105.69	102.5	92.93	85.25
Pop	-	-	-	-	-	24.62	27.71
Alternative	80.92	68.2	53.73	55.03	52.2	-	-
Classical	13.32	12.14	8.96	9.57	7.5	-	-
Jazz	11.79	11.78	8.78	11.08	8.1	-	-
Metal	50.48	38.73	32.55	32.21	31.9	-	-
New Age	2.94	2.35	1.66	1.93	1.7	-	-
Rap	33.41	26.44	27.33	28.25	24.2	-	-

DOWNLO

Sources
→ Show
→ Show

Release
January 20

Region
United Sta

Survey t
2008 to 20

Supplem
* Titles ma
Dance/Ele
Pop data
In 2013 ar
Hop.

These examples integrate cultural competence along with mathematical thinking by referencing pieces of information surrounding the student's life while also connecting to probability and statistics lessons. Here, math is used to determine the uniqueness of a family like hers, the likelihood of a certain outcome in a game she loves, as well as outliers in yearly album sales for a genre she enjoys.

Sociopolitical Consciousness: Addressing Racial Disparities in Home Ownership, Mental Health, & Criminal Justice Reform; Open-Ended Questions

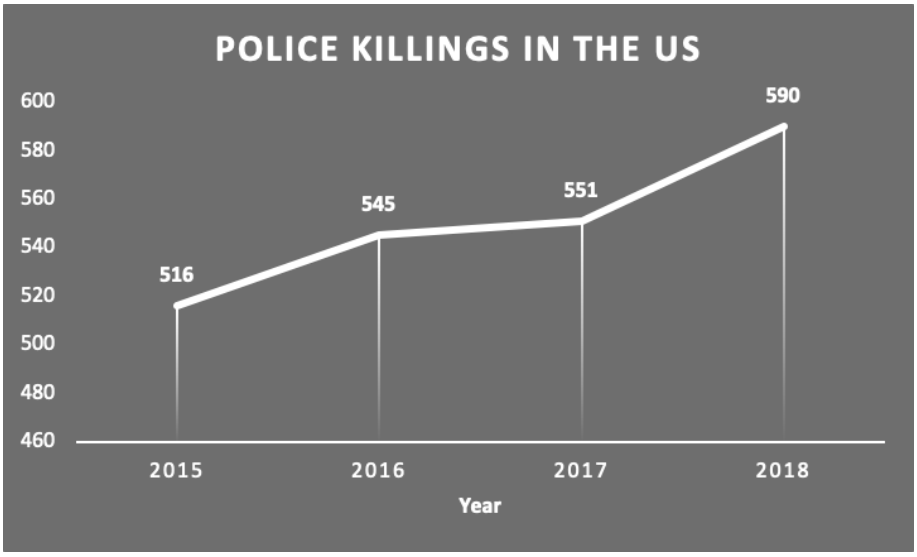
Problems designed to promote *sociopolitical consciousness* and deductively coded encouraged students to use their mathematics learning in class to address sociopolitical issues, particularly those that highlight injustices in the Black community. I incorporated the following topics into math problems: racial disparities in wealth, home ownership, police brutality, and other issues that the students brought up in the initial survey. Candace expressed interest and personal involvement in social justice causes; she works with a community organization that deals with conflict resolution between citizens and police. Policing was one of the top issues for Black voters during the 2020 presidential election (Clement, Balz, & Guskin, 2020). Hence, I designed the problem below to encourage students to use their learning on exponential growth to solve a problem on police killings.

According to AmericanProgress.org (https://mappingpoliceviolence.org), the line graph below shows the number of police killings across a 3-year period.

Does the graph illustrate more exponential growth or linear growth in police killings? Based on your answer, calculate either the exponential growth rate OR the linear slope.

Figure 5

Line Graph Provided to Student(s) Along with Police Brutality Problem Above



This problem prompted students to use their math learning to analyze real data on police killings. Granting students the opportunity to calculate the rate of police killings not only enhances their math skills but may also encourage them to think about the issue of police brutality on a deeper level. Mathematic calculations further emphasize the seriousness of the issue and can potentially further students' thinking about how the issue can be resolved.

Tiffany considered math to be useful when dealing with issues surrounding the cost of living and historical inequalities—based on race—in interest rates charged on loans. In composing a problem for her, I referenced OneUnited Bank, the country's largest Black-owned bank, whose goal is to improve financial literacy, build up neighborhoods, and support Black-owned businesses. The role of the bank in the context of the problem serves as a potential place where the student can save money for a home if the bank were to open up a branch where the student resides. I also mention the city of Milwaukee because it is the city where the student says she resides but is also considered one of the top cities where there is a high disparity in income between Black and white Americans (Schneider, 2015).

OneUnited Bank, the nation's largest Black-owned bank, is thinking of opening locations in Milwaukee. In seven years, you are interested in purchasing a house worth $120k and want to save up $24k for the down payment. OneUnited Bank offers their customers a

> BankBlack Savings account with APR 0.10%, compounded monthly. How much would you have to invest per month for 7 years in order to accumulate $24k in savings?

Jaylen, as indicated in her survey responses, aspired to one day own a community center and was very candid in talking about her struggle with mental health. She touched on the stigma surrounding mental health and counseling we often see in the Black community, the reluctance to say there is a problem and to get help (Fripp & Carlson, 2017). The topic of statistical correlations was in the course curriculum. I therefore took the opportunity to try to improve Jaylen's understanding of correlations by referencing the topic of mental health, a topic she seemed passionate about.

Open-ended questions were used in almost all problems promoting sociopolitical consciousness and critical thinking. The intent here was to get students to use their knowledge about the issue at hand to provide their own opinions on why the issue exists or how to solve the issue. Below are examples of these open-ended questions.

> Why do you think there is a big discrepancy in Black homeownership between these 2 cities?
>
> What do you think can be done to ensure the number of people killed by police will decrease over the years instead of increase?
>
> How do you think the increased presence of community centers will correlate to mental health?

Sociopolitical consciousness in education involves utilizing skills and concepts learned in the classroom to analyze, identify, and solve real-world issues (Ladson-Billings, 2014). The problems discussed above prompted students to use what they learned to tackle issues such as racial disparities in income, homeownership, criminal justice reform, mental health, etc. Based on the introductory survey responses, these were issues in which students expressed interest. Often, the topics referenced were also thoroughly discussed in mainstream media at the time. Real-world data and stats were provided to give full and accurate depiction of the issues at hand and to also provide the foundation for the mathematical problem-solving portion of the problems. Hence, the connection between mathematics and addressing pertinent and relevant issues was built in efforts to integrate sociopolitical consciousness in the classroom.

Academic Excellence: New Technology, Higher Difficulty Problems, and Scaffolding

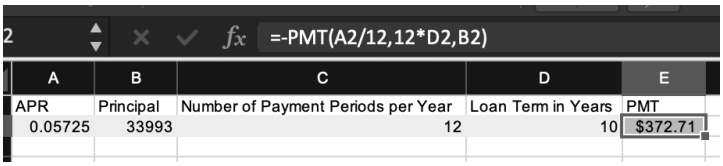
As an instructor, academic excellence was also a significant feature of my work. Some common themes appeared in the problems deductively coded as promoting *academic excellence.* To encourage academic excellence, I integrated supportive feedback and structures into the course design. These included encouraging students to use new technology and providing thorough guidance for high-difficulty problems when needed. For example, as part of the course, all students had to complete a portfolio project which required the use of Excel©. This project was not due until Week 6. Prior to that, the use of Excel as part of the curriculum during the first five weeks was limited. There were several instances where I took the opportunity to expand students' knowledge of Excel during that period. I introduced students to the PMT function in

Excel, which can be used to calculate the monthly payments of a loan given the loan value, the length of the loan, and the interest rates. Below is one example of a problem I designed for Candace and an excerpt of the Excel model itself.

> Problem for Candace: According to the US Department of Education, on average Black students owe $33,993 upon graduation compared to the national average of $29,669. Assuming the average APR is 5.725% for everyone, how much more are Black students paying every month across a 10-year repayment period? Here is a payment calculator I created in Excel. Using the calculator, we find that a $33,993 loan requires a monthly payment of $372.71. Can you finish the rest of the problem?

Figure 6

Snippet of Example Provided to Student Showing How to Use PMT Excel Formula to Calculate Loan Payment



In addition, when designing problems, I often went beyond the scope or the level of difficulty featured in the prescribed curriculum. My intent was to either broaden the students' understanding or require them to use their prior knowledge of math. In these instances, I made sure to either partially remind them of math concepts they may have learned in lower-level math courses or give them hints. Linear slope, for example, was not a topic included in the course curriculum but would be included in a lower-level class. For example, when I asked Jaylen to determine whether a data model on police brutality showed linear growth or exponential growth, The researcher provided a picture demonstrating the two and a formula on how to calculate linear growth.

Academic excellence in the context of CRP means stimulating intellectual growth in students (Ladson-Billings, 2014). The above examples show students were encouraged to go beyond the learning as outlined in the curriculum and connect their prior knowledge to new learning. Students were also given support and thorough explanations when they did not solve a problem correctly. These techniques in instruction and problem designing help to communicate that the instructor has confidence in students' ability to succeed, not just at learning the concepts outlined in the curriculum, but also to take their skills to the next level and grow as a math learner. Furthermore, the scaffolded support provided shows students that they are supported in the learning process, which may assist students in building the confidence needed to tackle new concepts.

Culturally Relevant Feedback: Personable, Caring, and Relatable

In this section, the researcher discussed types of feedback provided over the course of the study. When coding the feedback excerpts, the common themes that showed up were

"personable," "caring," and "relatable." The feedback went beyond simply letting students know if their answer was correct or why their answers were incorrect. Instead, I integrated my personal information about myself and my understandings related to the math problems whenever possible. In this way, I not only gathered the students' interests but expressed vulnerability in sharing my own. I drew upon prior research which shed light on the ways that CRP must be carried out in all elements of a teacher's practice (Hubert, 2014; Milner, 2016; Hambacher, 2018; Ladson-Billings, 2009) as I sought to situate learning and assessment within genuine, caring relationships. Below is one example where I express personal information about myself that is related to the topic being discussed.

> You raise some good points about community outreach when it comes to teaching people about investing. When I first learned about investing in stock, for instance, it was made to seem more complicated than it actually is. It was not until I met my fiancé when I really learned about it. My family and I come from a working-class background while his family came from an upper middle-class background. Therefore, he knew more about investing in stock and always advised me to invest in stock holding companies I liked to shop with. For certain clothing stores I found buying some shares of their stock and letting it sit long term was a better investment than simply buying clothes from them on a regular basis.

It was also important to acknowledge and empathize with the student's experience, what they are going through, and value their input on how to fix certain social justice issues which is heavily influenced based on their experience.

> Thank you for sharing your own personal struggle with mental health. Sending positive thoughts your way! Unemployment definitely is a correlating factor. When you open your community center, in addition to offering services that help with unemployment, financial instability, etc... do you plan on offering direct mental health counseling? I think that would be a great idea and given your passion for helping people, it will definitely go a long way in giving back. There are so many people suffering and sometimes all they need is someone to talk to.

During the summer and early fall of 2020, massive worldwide protests broke out in response to the high-profile police killings of Breonna Taylor and George Floyd. One of the course sessions I was teaching for this study happened during this period. In late September, a grand jury decided not to charge officers for Breonna's death. I reached out to Tiffany via email to offer words of encouragement or support.

> So far, your participation has been great and extremely helpful to my research. However, I wanted to reach out to you specifically about the most recent headlines regarding the Breonna Taylor verdict. The country is going through very hard times and people are hurting. Regardless of where you stand on the issue, the verdict, or whether you are aware of the incident, I want you to know that if you need to vent or express your feelings about the situation, or any other current events, and whether your focus on school is being impacted due to what is happening, please do not hesitate to contact me. I am here to help you succeed no matter what.

These above pieces of dialogue between the myself and the participants I deem culturally relevant. They possess the common characteristics of being personable, caring, and relatable in a way that aims to demonstrate connectedness with the students. Ladson-Billings (2009) argues for culturally relevant instructors to find ways to facilitate interaction outside of the classroom. Because I am teaching an online class and I do not live near the students, this would be difficult to do. However, if there is a way to communicate with students in a similar manner as one would outside the classroom, that can possibly lead to a level of connectedness between students and instructor akin to that found if there is in-person communication outside of the classroom. Telling students about myself, letting them know I am there for them, thanking them for being open, as well as comforting them on issues that might be impacting them in the real world are great ways to build the connectedness that is encouraged by CRP scholars.

Findings

In our analysis of the student data, we identified evidence of high engagement, confidence, and motivation among the student participants. We also identified various ways that students related these factors to their culturally relevant learning experiences.

High Engagement: Personable, Lengthy Responses & Explanation of Answers

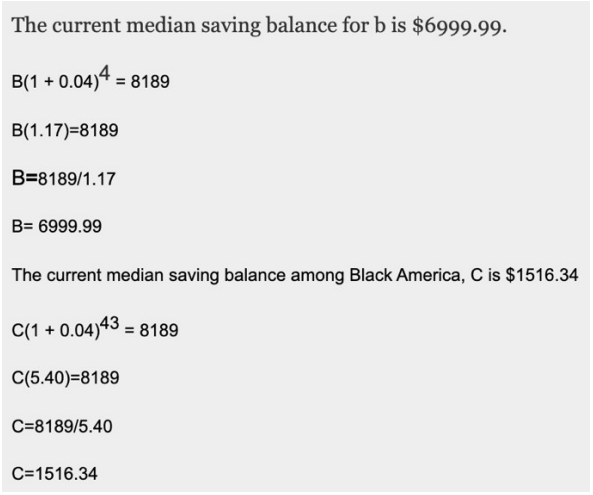
Examining student engagement as a measure of learning takes the focus off of scores and places it on the students themselves and their experience in the classroom. Student engagement has historically been shown to positively correlate with student achievement (Skinner, Wellborn, & Connell, 1990; Finn, Pannozzo, & Voelkl, 1995). Student engagement has been defined by looking at the length of time and amount of physical energy students spend on activities in the classroom. This includes the amount of effort students use to study and practice a subject, analyze and solve problems, and obtain feedback (Jacobi et al.,1987; Kuh, 2003).

There were some commonalities found in students' responses to the culturally relevant problems. First, students explained how they derived their mathematical answers and also provided thorough responses to questions. Their responses provided further insight into their lives and how their experience shaped their reaction to social justice issues presented. Additionally, although students were not required or given direction to show their work when answering the culturally relevant problems, for the most part they still showed their work and thoroughly explained their answers, exemplifying high levels of engagement exhibited in CRP problem solving.

A prime example of a student explaining their reasoning was Jaylen's response to the origami probability problem shown earlier. Jaylen did not simply state her final answer. Instead, she listed out all the possible outcomes of the origami game, picked the correct ones, and explained her reasoning. Below are a few more examples of students giving step-by-step explanations of their answers.

Figure 7

Examples of Students Providing Step-By-Step Solutions to Problems



> Based on the bar graph the 80% is correct. (88-49)/49 equals to 0.795918367, rounded it would be .80 = 80%. I don't agree with what it says about Black women because I think the number is higher for Black women than any other group. If my math is correct (2272-1018)/1018 =1.231827112 =123.1= 123%.

Below is one example of Jaylen providing lengthy answers, demonstrating their interest and engagement in talking about the social justice components of some problems. These pieces of dialogue demonstrated the student's personal knowledge of the issue, based on historical knowledge or experience, and what values they have that guide their proposed solutions to certain issues.

> The topic you brought is one i am most familiar with. I hope to open a community center to help with issues just as this one. I believe that offering my community assistance with issues that can lead to depression such as homelessness, unemployment, financial instability, and lack of resources can help tremendously. I have personally been one who has face severe depression disorder. Without the right treatment, support, willingness to recover and resources it can be hard for anyone to recover. I know community centers who are aware of the issue and know how to deliver the right assistance can help the mental health of individuals, and the community as a whole. An example of a positive correlation involving major depression disorder in Black American adults is the rise in unemployment causes a higher rate on major depression disorder. The more Black Americans become unemployed, they are unable to provide for themselves or find resources to help them, the more likely they are to face major depression disorder. More are unemployed ==> More facing depression.

Here, Jaylen was asked to provide an example of a contributing factor that correlates to the disproportionate number of Black American adults experiencing major depressive disorder. The

last three sentences in Jaylen's response directly answer the question. The first six sentences show information that was volunteered by the student on her own. Jaylen demonstrated comfort sharing her insight and experience which translates into her ability to explain her reasoning thoroughly in extensive responses. Such an example of meaningful engagement with the topic signifies high engagement. It is significant to highlight here that the level of engagement was higher in students who solved the CRP problems compared to students who answered traditional non-CRP questions.

When asked in the one-on-one interviews whether students felt the use of culturally relevant questions influenced their engagement in the classroom, all students indicated that they were more engaged because the questions were personally relevant to them or issues they cared about. Jaylen stated she liked the nature of the discussions, which included the addition of culturally relevant problems, and that she enjoyed relatable material. Joy is notable as an indicator of emotional engagement (Skinner, Furrer, Marchand, & Kindermann, 2008). As another example, Tiffany emphasized how relevant problems helped her to learn mathematics, stating:

> I think it was very relevant and it helped me understand. And it made me want to participate more knowing that you were culturally aware and you did... I don't know, it's just nice to know that somebody cares. So I think what you did was perfect and it was different than what I've ever experienced in a class.

Tiffany shared here that the CRP problems made her "want to participate more," which signify effort and exertion, indicators of behavior engagement (Skinner, Furrer, Marchand, & Kindermann, 2008).

Confidence and Motivation

Culturally relevant mathematics problems increased students' motivation to engage with mathematics and their confidence to do so. Each of the three participants expressed they were more eager to learn and solve problems due to the problems being more culturally relevant or addressing issues of interests. Students shared that CRP made them more curious and eager to engage with mathematics and to understand more about their culture and community through culturally relevant problem solving. Candace emphasized her motivation to learn when she shared the following:

> Like for this class, having culture relevant mathematics. I mean, it increased my curiosity, my when I want to learn [inaudible] because just [plain] mathematics, these things or these questions are not asked especially in relevance to our culture. So, I think that if this culturally relevant, then it would make [people] more intrigued to learn and ready to learn because it's in relation to their culture. It deals with their culture and what they deal with in life and in their community. So I think that'll be a big plus with mathematics.

Notably in this excerpt Candace compares her prior experience in mathematics, which she deemed as not being culturally relevant, to her experience during this study. She highlights the fact that CRP makes people more eager to learn and enthusiastic, something that she may not

have experienced previously. In addition, Jaylen added that the culturally relevant problems made her more interested in solving problems, stating:

> It was definitely related to what we were learning and it gave me more, like I said, more time to actually practice using the formula and it was interesting to find out... I was eager to find out, "Okay, what is the actual difference between the average savings and then Black American savings?" So it made the question something I was actually interested in answering.

In this quote, Jaylyn describes feeling "eager to find out" the answer to a culturally relevant problem. By emphasizing how she was "actually interested" in these problems, she indicates a comparison between prior courses she has taken and the course now that exposes her to culturally relevant problems.

Participants also expressed confidence in their mathematical ability to succeed and solve problems due to the use of culturally relevant problems. Jaylen expressed a sense of confidence in understanding mathematics problem solving through a shift in viewing math beyond solely numerical input. She stated:

> Before, it was just numbers. I can do the numbers, I can put the calculations in. Now it's more, okay not only can I do the calculations if I don't know the formula or something, I could put it into words that I can actually relate and then try to solve it that way.

Here, Jaylen seemingly discovers a new way of problem solving. If she comes across a problem she has trouble solving or does not know which formula to use, instead of giving up, the exposure to culturally relevant problems has given her the confidence to try or retry the question by putting the problems into a more familiar context. Often, when we have to use math outside of the classroom, we may not have access to formulas or theorems from a textbook. Rather we have to use logic, arithmetic, and math we are already familiar with to come up with a solution. Although our solutions are often based on existing formulas and theorems, sometimes unknowingly, the process of finding the correct solution in real world contexts can better prepare students to solve problems seen in the classroom.

Confidence seemed to be positively impacted when it comes to solving problems outside of the classroom as well. When asked whether the use of culturally relevant problems had increased Tiffany's confidence, she indicated it did as she felt she was now more suited to tackle real world problems that require math.

> It has increased it. I know further down the line when leasing cars or when paying back student loans, I now understand how interest rates come into play or even having a savings account. And I know that that is important and looking for banks that will actually apply to my end goal is, I didn't really have an understanding on it before. And now I will. I know that I can be more competent in calculating these things and looking at future outcomes and things like that.

Here, it is clear the use of culturally relevant problems provided Tiffany with the tools to better tackle problems outside of the classroom and to better understand concepts that would be required to make decisions in the real world. She is now more confident when it comes to making decisions such as leasing a car or taking out and paying back a loan due to a greater understanding of concepts such as interest rates.

Discussion

This research explicates what CRP mathematics looks like for Black learners in an online higher education course. In a very short, 7-week online learning environment, Lauren was able to work creatively to develop forms of caring, trust, and relatability that extended throughout the curricula, pedagogy, and assessment. The discussion highlights and further contextualizes these significant factors by answering the posed research questions.

> RQ1 How does an instructor design and implement CRP for Black undergraduate learners in an online mathematics classroom?

Features of Culturally Relevant Problems

Problems intended to encourage cultural competence referenced various features of students' personal lives, hobbies, and current events. The bridging of the mathematics present in students' life outside of school with the math in the curriculum was consistent with the prior studies such as those of Corp (2017), Nasir (2000), and Taylor (2009). Sociopolitical consciousness was promoted when problems addressed racial disparities in wealth, homeownership, criminal justice, and other issues students expressed interest in. These themes were similar to those found in prior works by Hubert (2018), Gutstein (2003), Kokka (2019) and Langlie (2008). The focus on topics students themselves found interest in when designing problems was highly influenced by Hambacher (2018), Flores-Koulish, & Shiller, (2020), and Watson, Sealey-Ruiz, & Jackson, (2016).

Asking open-ended questions where students were provided leeway to give their take on the issues was a dominant feature in these problems. This was a common feature also found in Tate's (1995) study. Academic excellence in students was stimulated through the use of new technology and higher difficulty exercises, with guidance provided alongside. Having high expectations for students is an essential feature in works highlighting Culturally Relevant Critical Teacher Care (Hambacher, 2018; Hambacher & Bondy, 2016; Ware, 2006). Lauren's objective in the course was to convey to students that who they are matters, they have a voice in addressing pertinent issues that can be supported by math, and their instructor believes in their ability to succeed.

Open and Relatable Feedback

When providing feedback to students, it was significant to go beyond letting students know their answers were correct or simply say "good job." Lauren used feedback as an opportunity to help students get to know her and see her as relatable. Here, the need to build connectedness with the students was consistent with Maloney & Matthews's (2020) study. Additionally, Lauren was careful to make sure she acknowledged the validity of students' experiences and viewpoints on certain issues, similar to the works of Collins (1991), Roberts

(2010), Hambacher and Bondy (2016), and Acosta (2013). This approach was also partially influenced by Lauren's own experience as a STEM student and as someone who has worked in corporate America—where in both experiences she witnessed the acute underrepresentation of Black students and employees. For example, during the protests in support of Breonna Taylor and George Floyd, Lauren's supervisor at her job scheduled a meeting to check in with everyone on his team to see how they were doing. At the meeting, everyone was instructed to be open and honest about the issues and conversations the nation was having at the moment regarding race, but as the only Black American in the meeting, Lauren felt hesitant to speak up. She had many thoughts, but during the meeting she froze, unable to voice her thoughts. In retrospect, she identified that she was uncomfortable and felt unsafe speaking up as the sole Black person in the meeting. Would she be "representing" everyone? Would she make others uncomfortable? Why was she concerned about their comfort on matters of racial inequality? Would she be perceived as an "angry Black woman?" Experiences such as this are unfortunately not uncommon for Lauren and other Black folks who often face discomfort, racism, and oppressive circumstances while navigating historically white institutions. However, this experience left an impression upon Lauren. As a teacher, she was in a position of authority relative to her students, and she utilized the opportunity to develop something different for the students. Considering this racialized experience and applying it to her teaching, Lauren wanted to ensure she granted a forum for students to be open. Further, she knew it would be beneficial for her to make the first step in developing a comfortable classroom culture since students may otherwise be hesitant to speak openly. It was imperative to recognize potential mutual vulnerabilities when providing feedback as part of the course's design. In particular, the email Lauren sent to one student regarding the grand jury's decision not to indict the officers who killed Breonna Taylor was sent to the student in private. While all other communication in online forums was public (all students in the course could see it), this communication was different. While the student did not respond to the email, Lauren wanted her to know she could express her feelings, if any, about the situation without the pressure of feeling nervous or judged by peers.

> RQ2 What is the impact of CRP on Black learners' engagement, motivation, and confidence?

Students were engaged in problem solving, evident from their lengthy answers, detailed explanations, and willingness to be personable. When asked what prompted the nature of these responses, students indicated they appreciated having access to problems that referenced their personal lives and current events. Students felt like the problems were designed purposely for them. Students felt like the questions themselves granted them more opportunities to master the material being covered, making them more motivated to learn. Furthermore, the additional problems made them more confident in their mathematical ability. Once problems were designed to be more relatable to them, the confidence students expressed in the issues and topics they cared about spilled over into confidence towards the math itself. Overall, the participants seemed to respond positively to the study, specifically with respect to their confidence, motivation, and engagement levels. These results are consistent with studies focusing on the use of CRP in in-person K-12 learning (Corp, 2017; Hubert, 2014; Yu et al., 2021).

Distinguishing Features

This study's emphasis on defining what culturally relevant feedback looks like in online learning is one factor that makes it distinct from prior research. Because online instructors don't interact with students in person, feedback to students in an online environment will look different than in a traditional classroom. Arguably, assessment should possibly be more thorough in virtual classrooms to ensure students are engaged and to maintain retention that may be compromised when students learn virtually. Studies show feedback is even more important in online learning due to its correlation to the learner's performance and satisfaction (Dennen et al., 2007; Espasa & Meneses, 2010). Since a lot of online learning consists of students doing self-guided work (e.g., spending a lot of time reading a textbook on their own), quality feedback is of the upmost importance. If we want students to be engaged, we as instructors should also show we are engaged in the learning process along with them. CRP instructors who are obligated to be open and caring have to go beyond simply creating culturally relevant problems. The act of creating problems that are culturally relevant is not enough. Rather, the dialogue that happens after a student solves a problem should also exhibit care and be personable, qualities argued for by CRP scholars (Ladson-Billings, 2009; Hambacher, 2018). This study also differs from other works since it gives personal insight to the mindset and experience of Lauren as a Black female STEM worker and instructor and how that impacts her behavior in the classroom, including the nature of her feedback.

Lastly, my study and its findings uniquely point out what factors of the online learning environment itself can be used successfully to enact CRP. As discussed briefly before, my use of CRP was more of an add-on feature to the curriculum. Meaning, the curriculum in the online classes I taught was already preset by the school and the required textbook readings and homework assignments built into the course did not contain any CRP problems. However, I was still able to utilize the discussion board forums and the written reflection assignments to introduce CRP to the study's participants. In my experience, discussion board prompts usually ask students to respond to one particular problem or question. They are often set up to give students open access before making their initial post. In other words, before a student makes their initial post, they could look at what their classmates said and just repeat their peers' answers when making their own initial posts. This can take away an opportunity for learning or the ability to master the material if the student does not have to come up with their own response. Using the discussion board forums to assign unique CRP problems in my reply posts granted me more of an opportunity to personalize the student's experience and for the students to enhance their learning. The CRP problems I designed were personalized to the individual and therefore required the students to do the work to come up with their own answers. These problems afforded the student more time to practice the material learned that week and hopefully master the content. Hence, my study shows if instructors find they do not have agency to change the course's default curriculum to be more culturally relevant, the discussion board forums can still be used as an effective tool to implement CRP.

Conclusion

Implication

While attention has been paid to achievement levels of Black learners in mathematics by various scholars, disparities continue to exist. Furthermore, these disparities have worsened due to the COVID pandemic. Due to school shutdowns, students of color were about three to five months behind in their mathematical learning, compared to white students who were one to three months behind. While some schools have reopened to either full in-person or hybrid learning, Black students have been more likely to remain full-time online learners (Dorn et al., 2021). Further, research has shown that the technological disparities have been heightened by the pandemic, leading to even greater inequality than in pre-pandemic times (Golden et al., 2023).

What then should our responses entail in online learning environments where there may be heightened potential for exacerbating rather than reducing racial disparities in learning mathematics? It is imperative for educators, particularly at the undergraduate level, to figure out how to design an online classroom environment that engages and retains Black students while learning mathematics. This study reveals that CRP provides one significant answer to online learning. By (1) utilizing online introductory surveys to get to know the students, (2) designing problems that connect the curriculum to students' culture, interests, and experiences, (3) taking advantage of discussion board forums and reflection tasks in the assignment of culturally relevant problems, and (4) providing prompt and caring feedback, we see that engagement, confidence, and motivation are positively impacted among Black learners, providing hope that we can close the disparities even in online environments.

Limitations

Since the study focuses solely on students who identify as Black or of African descent, we do not have results demonstrating how non-Black students would react to the course. If we used the exact type of problems as used in this study, but assigned them to all the students in the class, what impacts might be seen? Would we see positive results in engagement, confidence, and motivation for the entire class? Would non-Black students accept or reject this pedagogical approach and accept or reject a Black female instructor who utilizes CRP? These are essential questions since the experiences of students and instructors in CRP classrooms in higher education is situated within the broader context of racial politics within the United States. Most Black undergraduate students, for instance, attend predominantly white institutions (PWI) and attend math courses where they are the minority.

Future Studies

Future studies should also consider examining what collaboration looks like in a culturally relevant online mathematics course. Ladson-Billings (2009) argues that culturally relevant teachers advocate for collaboration among students and that students should take responsibility for their peers' success. The question of how does this show up in an online classroom where students are not face-to-face with each other is an important one. Online discussion boards encourage students to communicate with one another. However, many times students make their own response to a question, an initial post, and when they have to respond to others, they simply state whether they agree or disagree with what another student says. Are students really learning how to solve problems from one another ? And if so, what deems this collaborative learning culturally relevant as opposed to traditional?

Final Thoughts

The legendary B.B. King once said, “The beautiful thing about learning is that nobody can take it away from you.” To the learner, that is an inspirational quote that puts the agency of learning into his or her own hands. But what does that mean to the educator? Does it simply mean educators should repeat this quote to their students to inspire learning? Well, yes, but it can mean something deeper. To successful educators of Black online learners who choose to use CRP, it means we should convey to students that what they learn does not simply come from a textbook. Rather, who we are plays an important role. Our culture, interests, experiences, and prior knowledge is relevant to their learning. Black online learners will always have a sense of who they are, and as long as educators provide students an adequate learning environment where their culture, experience, and interests are viewed as an asset to the curriculum, learning is inevitable. We are enough and we matter, including in online math class.

Declarations

This study was approved by the University at Buffalo’s IRB (Protocol number: STUDY00004111).

Mrs. Lauren Hennings and Dr. Alexandra Schindel declare no conflicts of interest.

References

Acosta, M. (2013). *A culture-focused study with accomplished black educators on pedagogical excellence for African American children (Unpublished doctoral dissertation).* University of Florida.

Adelman, C. (2006). *The toolbox revisited: paths to degree completion from high school through college.* US Department of Education

Anderson, E. & D. Kim. (2006). *Increasing the success of minority students in science and technology.* American Council on Education.

Anderson, Herr, K., & Nihlen, A. S. (2007). *Studying your own school an educator's guide to practitioner action research* (2nd ed.). Corwin.

Aronson, B., & Laughter, J. (2016). The theory and practice of culturally relevant education: a synthesis of research across content areas. *Review of Educational Research*, *86*(1), 163–206. https://doi.org/10.3102/0034654315582066

Baker, K. (2016). Culturally responsive mathematics teaching and young learners. *Journal of Interdisciplinary Teacher Leadership*, *1*(1).

Battey, D., & Neal, R. A. (2018). Detailing relational interactions in urban elementary mathematics classrooms. *Mathematics Teacher Education & Development*, *20*(1), 23-42.

Berry, R. Q., III, & McClain, O. L. (2009). Contrasting pedagogical styles and their impact on African American students. In D. B. Martin (Ed.), *Mathematics teaching, learning, and liberation in the lives of Black children* (pp. 123–144). Routledge.

Boaler, J. (2008). Promoting "relational equity" and high mathematics achievement through an innovative mixed-ability approach. *British Educational Research Journal, 34*, 167–194. https://doi.org/10.1080/01411920701532145.

Boaler, J., & Staples, M. (2008). Creating mathematical futures through an equitable teaching approach: The case of railside school. *Teachers College Record, 110*, 608–645.

Bonner, E. P., & Adams, T. L. (2012). Culturally responsive teaching in the context of mathematics: A grounded theory case study. *Journal of Mathematics Teacher Education, 15*, 25–38. https://doi.org/10.1007/s10857-011-9198-4

Bonner, E. P. (2014). Investigating practices of highly successful mathematics teachers of traditionally underserved students. *Educational Studies in Mathematics, 86*, 377–399. https://doi.org/10.1007/s10649-014-9533-7

Cholewa, B., Goodman, R. D., West-Olatunji, C., & Amatea, E. (2014). A qualitative examination of the impact of culturally responsive educational practices on the

psychological well-being of students of color. *The Urban Review, 46*(4), 574-596. doi:10.1007/s11256-014-0272

Clement, S., Balz, D., & Guskin, E. (2020). Black Americans say racism, policing top issues for November, favor Biden by huge margin, Post-Ipsos poll finds: Trump is seen in starkly negative terms, while there is less enthusiasm for Biden among younger Black Americans. *The Washington Post*.

Cochran-Smith, & Lytle, S. L. (2009). *Inquiry as stance: Practitioner research for the next generation.* Teachers College Press.

Collins, P. H. (1991). *Black feminist thought: Knowledge, consciousness, and the politics of empowerment*. Routledge & Keagan Paul.

Corey, D. L., & Bower, B. L. (2005). The experiences of an African American male learning mathematics in the traditional and the online classroom--a case study. *The Journal of Negro Education*, *74*(4), 321–331.

Corp, A. (2017). Using culturally responsive stories in mathematics: Responses from the target audience. *School Science and Mathematics, 117*(7-8), 295–306. https://doi.org/10.1111/ssm.12247

Dennen, V. P., Aubteen Darabi, A., & Smith, L. J. (2007). Instructor-learner interaction in online courses: The relative perceived importance of particular instructor actions on performance and satisfaction. *Distance Education, 28*(1), 65–79. https://doi.org/10.1080/01587910701305319

Dorn, E., Hancock, B., Sarakatsannis, J., & Viruleg, E. (2021, March 1). COVID-19 and learning loss—disparities grow and students need help. *McKinsey & Company*. https://www.mckinsey.com/industries/public-and-social-sector/our-insights/covid-19-and-learning-loss-disparities-grow-and-students-need-help

Downing, G.A., & McCoy, W.N. (2021). Exploring mathematics of the sociopolitical through culturally relevant pedagogy in a college algebra course at a historically Black college/university. *Journal of Urban Mathematics Education, 14*(1), 45-70

Driver, & Powell, S. R. (2017). Culturally and linguistically responsive schema intervention: improving word problem solving for English language learners with mathematics difficulty. *Learning Disability Quarterly*, *40*(1), 41–53. https://doi.org/10.1177/0731948716646730

Enyedy & Mukhopadhyay, S. (2007). They don't show nothing I didn't know: emergent tensions between culturally relevant pedagogy and mathematics pedagogy. *The Journal of the Learning Sciences*, *16*(2), 139–174. https://doi.org/10.1080/10508400701193671

Espasa, A., & Meneses, J. (2010). Analysing feedback processes in an online teaching and learning environment: an exploratory study. *Higher Education*, *59*(3), 277–292. https://doi.org/10.1007/s10734-009-9247-4

Finn, J. D., Pannozzo, G. M., & Voelkl, K. E. (1995). Disruptive and inattentive-withdrawn behavior and achievement among fourth graders. *The Elementary School Journal*, *95*(5), 421–434. https://doi.org/10.1086/461853

Flores-Koulish, & Shiller, J. T. (2020). Critical classrooms matter: Baltimore teachers' pedagogical response after the death of Freddie Gray. *Education and Urban Society, 52*(6), 984–1007. https://doi.org/10.1177/0013124519889042

Frankenstein, M. (1989). *Relearning mathematics: A different third R--radical math(s)*. Free Association Books.

Fripp, J., & Carlson, R. (2017). Exploring the influence of attitude and stigma on participation of African American and Latino populations in mental health services. *Journal of Multicultural Counseling and Development, 45*(2), 80–94. https://doi.org/10.1002/jmcd.12066

Fulton, R. (2009). *A case study of culturally responsive teaching in middle school mathematics* (Doctoral dissertation). ProQuest Dissertations & Theses Global database. (UMI No. 3372472)

Gilligan, C. (1982) *In a different voice.* Harvard University Press.

Golden, A. R., Srisarajivakul, E. N., Hasselle, A. J., Pfund, R. A., & Knox, J. (2023). What was a gap is now a chasm: Remote schooling, the digital divide, and educational inequities resulting from the COVID-19 pandemic. *Current Opinion in Psychology*, *52*, 101632-101637. https://doi.org/10.1016/j.copsyc.2023.101632

Greer, B., Mukhopadhyay, S., Powell, A. B., & Nelson-Barber, S. (2009). *Culturally responsive mathematics education.* Routledge.

Gregson, S. A. (2013) Negotiating social justice teaching: one full-time teacher's practice viewed from the trenches. *Journal for Research in Mathematics Education, 44*(1), 164–198. https://doi.org/10.5951/jresematheduc.44.1.0164

Gutiérrez, R. (1999). Advancing urban Latina/o youth in mathematics: Lessons from an effective high school mathematics department. *The Urban Review, 31,* 263–281. https://doi.org/10.1023/a:10232 24027473

Gutiérrez, R. (2002). Beyond essentialism: The complexity of language in teaching mathematics to Latina/o students. *American Educational Research Journal, 39*, 1047–1088. https://doi.org/10.3102/000283120390041047.

Gutiérrez, R. (2013). The sociopolitical turn in mathematics education. *Journal for Research in Mathematics Education, 44*(1), 37–68. https://doi.org/10.5951/jresematheduc.44.1.0037.

Gutstein. (2016). "Our issues, our people—math as our weapon": critical mathematics in a Chicago neighborhood high school. *Journal for Research in Mathematics Education, 47*(5), 454–504. https://doi.org/10.5951/jresematheduc.47.5.0454

Gutstein, Lipman, P., Hernandez, P., & de los Reyes, R. (1997). Culturally relevant mathematics teaching in a Mexican American context. *Journal for Research in Mathematics Education*, *28*(6), 709–737. https://doi.org/10.2307/749639

Gutstein, E. (2003). Teaching and learning mathematics for social justice in an urban, Latino school. *Journal for Research in Mathematics Education, 34*(1), 37–73. https://doi.org/10.2307/30034699

Gutstein, E., & Peterson, B. (2005). *Rethinking mathematics: Teaching social justice by the Numbers.* Rethinking Schools.

Gutstein, E. (2006). *Reading and writing the world with mathematics: Toward a pedagogy for social justice*. Routledge.

Hambacher, & Bondy, E. (2016). Creating communities of culturally relevant critical teacher care. *Action in Teacher Education*, *38*(4), 327–343. https://doi.org/10.1080/01626620.2016.1226206

Hambacher. (2018). Resisting punitive school discipline: perspectives and practices of exemplary urban elementary teachers. *International Journal of Qualitative Studies in Education*, *31*(2), 102–118. https://doi.org/10.1080/09518398.2017.1349958

Harper, F. (2019). A qualitative metasynthesis of teaching mathematics for social justice in action: pitfalls and promises of practice. *Journal for Research in Mathematics Education*, *50*(3), 268–310. https://doi.org/10.5951/jresematheduc.50.3.0268

Heitner, K. L., & Jennings, M. (2016). Culturally responsive teaching knowledge and practices of online faculty. *Online Learning, 20*(4), 54-78. https://doi.org/10.24059/olj.v20i4.1043

Hubert, T. L. (2014). Learners of mathematics: High school students' perspectives of culturally relevant mathematics pedagogy. *Journal of African American Studies*, *18*(3), 324-336. https://doi.org/10.1007/s12111-013-9273-2

Irizarry, J. G. & Antrop-Gonzalez, R. (2008). RicanStructing the discourse and promoting school success: extending a theory of culturally responsive pedagogy for diasporicans. *Hispanic Heath Care International, 6(*4), 172-184

Jackson, C. (2013). Elementary mathematics teachers' knowledge of equity pedagogy. *Current Issues in Education, 16*(1), 1–13.

Jacobi, M., Astin, A., Ayala, F., Jr. (1987). *College student outcomes assessment.* Clearinghouse on Higher Education.

Jett, C. C. (2013). Culturally responsive collegiate mathematics education: implications for African American students. *Interdisciplinary Journal of Teaching and Learning, 3*(2), 102-116.

Johnson, A., & Elliott, S. (2020). Culturally relevant pedagogy: a model to guide cultural transformation in STEM departments. *Journal of Microbiology & Biology Education, 21*(1), 5–16. https://doi.org/10.1128/jmbe.v21i1.2097

Jones, F. C. (1982) Dunbar high school of Little Rock: a model of educational excellence, *Phi Delta Kappan, 63*(8), 540–542.

Kim, C., Park, S., & Cozart, J. (2014). Affective and motivational factors of learning in online mathematics courses. *British Journal of Educational Technology*, *45*(1), 171–185. https://doi.org/10.1111/j.1467-8535.2012.01382.x

King Miller, B. A. (2015). Effective teachers: Culturally relevant teaching from the voices of Afro-Caribbean immigrant females in STEM. *SAGE Open, 5*(3), https://doi.org/10.1177/2158244015603427

Kokka, K. (2019). Healing-informed social justice mathematics: promoting students' sociopolitical consciousness and well-being in mathematics class. *Urban Education, 54*(9), 1179–1209. https://doi.org/10.1177/0042085918806947

Kuh, G. D. (2003). What we're learning about student engagement from NSSE. *Change, 35,* 24–31.

Kumi-Yeboah, A., & Amponsah, S. (2023). An exploratory study of instructors' perceptions on inclusion of culturally responsive pedagogy in online education. *British Journal of Educational Technology, 54*(4), 878–897. https://doi.org/10.1111/bjet.13299

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, *32*(3), 465–491. https://doi.org/10.3102/00028312032003465

Ladson-Billings, G. (2006). From the achievement gap to the education debt: understanding achievement in U.S. schools. *Educational Researcher, 35*(7), 3–12. https://doi.org/10.3102/0013189X035007003

Ladson-Billings, G. (2009). *The dreamkeepers successful teachers of African American children.* (2nd ed.). Jossey-Bass Publishers.

Ladson-Billings, G. (2014). Culturally relevant pedagogy 2.0: a.k.a. the remix. *Harvard Educational Review*, *84*(1), 74–84. https://doi.org/10.17763/haer.84.1.p2rj131485484751

Langlie. (2008). *The effect of culturally relevant pedagogy on the mathematics achievement of black and Hispanic high school students*. ProQuest Dissertations Publishing.

Laughter, J. C. & Adams, A. D. (2012). Culturally relevant science teaching in middle school. *Urban Education, 47*(6), 1106–1134. https://doi.org/10.1177/0042085912454443

Majewska, & Vereen, E. (2021). Fostering student-student interactions in a first-year experience course taught online during the COVID-19 pandemic. *Journal of Microbiology & Biology Education*, *22*(1). https://doi.org/10.1128/jmbe.v22i1.2417

Maloney, & Matthews, J. S. (2020). Teacher care and students' sense of connectedness in the urban mathematics classroom. *Journal for Research in Mathematics Education*, *51*(4), 399–432. https://doi.org/10.5951/jresematheduc-2020-0044

Martell. (2013). Race and histories: examining culturally relevant teaching in the U.S. history classroom. *Theory and Research in Social Education, 41*(1), 65–88. https://doi.org/10.1080/00933104.2013.755745

Masterson, Victoria. (2021). These are the degrees that will earn you the most money when you graduate - and the ones that won't. *World Economic Forum*, https://www.weforum.org/agenda/2021/10/stem-degrees-most-valuable/.

Matthews, J. S., & López, F. (2018). Speaking their language: The role of cultural content integration and heritage language for academic achievement among Latino children. *Contemporary Educational Psychology*. https://doi.org/10.1016/j.cedpsych.2018.01.005.

McKernan. (1991). *Curriculum action research :A handbook of methods and resources for the reflective practitioner*. St. Martin's Press.

McLoughlin, C. (2001). Inclusivity and alignment: Principles of pedagogy, task and assessment decisions. *Distance Education, 22*(1), 7-29.

McMillian, M. M. (2003). Was no child left behind 'wise schooling' for African American male students? *The High School Journal, 87*(2), 25–33.

Milner, H. (2016). A black male teacher's culturally responsive practices. *The Journal of Negro Education, 85*(4), 417-432.

Minor. (2014). Racial differences in teacher perception of student ability. *Teachers College Record (1970), 116*(10), 1–22. https://doi.org/10.1177/016146811411601004

Morrison, K. A., Robbins, H. H., & Rose, D. G. (2008). Operationalizing culturally relevant pedagogy: a synthesis of classroom-based research. *Equity & Excellence in Education*, *41*(4), 433–452. https://doi.org/10.1080/10665680802400006

Morton, & Riegle-Crumb, C. (2020). Is school racial/ethnic composition associated with content coverage in algebra? *Educational Researcher, 49*(6), 441–447. https://doi.org/10.3102/0013189X20931123

Nasir, N. S. (2000). "Points ain't everything": emergent goals and average and percent understandings in the play of basketball among African American students. *Anthropology & Education Quarterly, 31*(3), 283–305.

National Center for Education Statistics. (2015). *National Assessment of Educational Progress: An overview of NAEP*. National Center for Education Statistics, Institute of Education Sciences, U.S. Dept. of Education.

Noddings, N. (1984). *Caring: A feminine approach to ethics and moral education.* University of California Press.

Noddings, N. (2002). *Starting at home: Caring and social policy.* University of California Press

Pattillo-McCoy, M. (1998) Church culture as a strategy of action in the Black community. *American Sociological Review*, *63*(6) 767–84. https://doi.org/10.2307/2657500

Roberts, M. A. (2010). Toward a theory of culturally relevant critical teacher care: African American teachers' definitions and perceptions of care for African American students. *Journal of Moral Education, 39*(4), 449–467. https://doi.org/10.1080/03057241003754922

Ruef, Jacob, M. M., Walker, G. K., & Beavert, V. R. (2020). Why indigenous languages matter for mathematics education: a case study of Ichishkíin. *Educational Studies in Mathematics, 104*(3), 313–332. https://doi.org/10.1007/s10649-020-09957-0

Saldaña, J., & Omasta, M. (2018). *Qualitative research: Analyzing life.* SAGE.

Schneider, D. (2015). The worst place in the U.S. to be black is. *Dollars & Sense,* 321, 13–19.

Skiba, R. J., Horner, R. H., Chung, C., Karega Rausch, M., May, S. L., & Tobin, T. (2011). Race is not neutral: A national investigation of African American and Latino disproportionality in school discipline. *School Psychology Review,* 40, 85–107.

Skinner, E. A., Wellborn, J. G., & Connell, J. P. (1990). What it takes to do well in school and whether I've got it: a process model of perceived control and children's engagement and achievement in school. *Journal of Educational Psychology*, *82*(1), 22–32. https://doi.org/10.1037/0022-0663.82.1.22

Skinner, E., Furrer, C., Marchand, G., & Kindermann, T. (2008). engagement and disaffection in the classroom: part of a larger motivational dynamic? *Journal of Educational Psychology*, *100*(4), 765–781. https://doi.org/10.1037/a0012840

Smith, & Ayers, D. F. (2006). Culturally responsive pedagogy and online learning: implications for the globalized community college. *Community College Journal of Research and Practice*, *30*(5-6), 401–415. https://doi.org/10.1080/10668920500442125

Tate. (1995). Returning to the root: A culturally relevant approach to mathematics pedagogy. *Theory into Practice*, *34*(3), 166–173. https://doi.org/10.1080/00405849509543676

Taylor, E. V. (2009). The purchasing practice of low-income students: The relationship to mathematical development. *The Journal of the Learning Sciences, 18*(3), 370–415.

Thomas, C. A., & Berry, R. Q. (2019). A qualitative metasynthesis of culturally relevant pedagogy & culturally responsive teaching: unpacking mathematics teaching practices. *Journal of Mathematics Education at Teachers College*, *10*(1), 21-30. https://doi.org/10.7916/jmetc.v10i1.1668

Ware, F. (2006) Warm demander pedagogy: Culturally responsive teaching that supports a culture of achievement for African American students, *Urban Education, 41*(4), 427–456.

Watson, Sealey-Ruiz, Y., & Jackson, I. (2016). Daring to care: the role of culturally relevant care in mentoring Black and Latino male high school students. *Race, Ethnicity and Education*, *19*(5), 980–1002. https://doi.org/10.1080/13613324.2014.911169

Woodley, X., Hernandez, C., Parra, J., & Negash, B. (2017). Celebrating difference: best practices in culturally responsive teaching online. *TechTrends, 61*(5), 470–478. https://doi.org/10.1007/s11528-017-0207-z

Xu, D., & Smith Jaggars, S. (2014). Performance gaps between online and face-to-face courses: differences across types of students and academic subject areas. *The Journal of Higher Education, 85*(5), 633–659. http://muse.jhu.edu/journals/journal_of_higher_education/v085/85.5.xu.html

Yu, Liu, Y., Soto-Lara, S., Puente, K., Carranza, P., Pantano, A., & Simpkins, S. D. (2021). Culturally responsive practices: insights from a high-quality math afterschool program serving underprivileged Latinx youth. *American Journal of Community Psychology*, *68*(3-4), 323–339. https://doi.org/10.1002/ajcp.12518

Yull, D. (2013). Moving beyond the barrier of mathematics and engaging culturally relevant pedagogy in the classroom for racial and ethnic minority stem students in community colleges. (2013). In Palmer, R. T. & Wood, J. L. (Eds.), *Community colleges and STEM* (pp. 143–158). Routledge.