



A Systematic Review of Culturally Relevant Pedagogy in Mathematics Teacher Education: Methods, Successes, and Room for Improvement

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Abstract: With diversity increasing in United States public schools, teachers need to be prepared to deliver high quality mathematics instruction to culturally and linguistically diverse students. Culturally relevant pedagogy offers a framework for teachers to address the needs of diverse students by using their cultural backgrounds as an asset to building mathematics knowledge. This study used a systematic review method to compile and analyze the results of studies in culturally relevant mathematics professional development trainings and courses delivered to pre-service and in-service teachers. The findings from all studies point to a common theme that teachers are not fully equipped to enact all components of culturally relevant pedagogy in their instruction. Implications from this study suggest that teachers require more modeling of concrete applications to employ culturally relevant pedagogy in mathematics education.

Keywords: culturally relevant pedagogy, mathematics teachers, professional development, teacher education.

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Introduction

As the United States becomes increasingly diverse, the education system must adapt to reflect students' cultural and linguistic backgrounds. Currently, there is a wide achievement gap between students of color and their counterparts in mathematics (Ukpokodu, 2011). Some factors that contribute to this gap include high rates of teacher turnover in low-income schools, lack of diversity among teachers, and ill-prepared teachers in the urban context (Ladson-Billings, 1997; Leonard et al., 2019; Males et al., 2020). Tate (1995) explained, "failing to provide African-American and Latinx students with a mathematics curriculum and instruction centered on their experiences, culture, and traditions is a deterrent to the achievement of equity in mathematics education" (pp. 167-168). Culturally relevant pedagogy (CRP) is one tool that mathematics educators can use to combat racism by providing high-quality and meaningful instruction to students of color.

CRP incorporates students' culture and background into the mathematics curriculum by focusing on topics and issues that are relevant to students' lives (Voigt et al., 2020). This method of instruction originated as a response to the inequities found in urban high-need schools, where there are larger minority and low-income student populations (Tate, 1995). Studies have found that CRP leads to increased student engagement, better mathematics performance, and more positive attitudes toward mathematics (Hubert, 2014; Voigt et al., 2020; Yu, 2022). The aim of this paper is to identify and describe what mathematics teacher preparation programs are doing well in regards to providing information on CRP and what educator preparation programs can do to create culturally relevant mathematics teachers. The findings of this study would be useful for teacher education programs to prepare future teachers for work in high-needs schools with diverse populations.

Background of the Problem

Racial disparity in mathematics education persists through biased tracking practices, lack of diversity among mathematics teachers, a shortage of qualified teachers specifically in low-income schools, and Eurocentric curriculum (Ladson-Billings, 1997; Taylor, 2020; Ukpokodu, 2011). CRP has the potential to transform the sphere of mathematics education by addressing these equity issues, however there are multiple challenges that educators face to prepare teachers for this role. Many teacher preparation and certification programs require a multicultural education course, but the instruction is often superficial or surface-level, lacking real application, and leaving teachers confused about what constitutes CRP enactment (Ladson-Billings, 1998). Evidence from previous studies have shown that pre-service teachers that learn about CRP do not successfully incorporate the theory into their practice (Brown et al., 2019). This issue is especially true for mathematics teachers, who typically receive less exposure to practical examples of CRP since much of the research has been focused on subject areas such as literature and history.

Some solutions to the problems outlined above include professional modeling, service-learning, self-reflection, lesson studies, and mentorships (Gay & Kirkland, 2003; Leonard et al., 2019; Rosner-Salazar, 2003; Taylor, 2020). However, there is little agreement on which of these strategies are the most effective for ensuring that pre-service teachers continue CRP practices in their teaching careers (Morrison et al., 2022). Since most research studies can only focus on one or two methods of instruction at a time, and are held to varying time restraints, this paper systematically reviewed the existing literature surrounding CRP in mathematics teacher education to gather data over multiple methods and learning environments. The data was then organized and analyzed to seek answers to the following research questions:

1. In what ways do mathematics teachers apply CRP after receiving training from a course or professional development program?
2. How do teacher educators instruct teachers about CRP in mathematics teacher preparation?
3. Which teaching strategies are most successful for the continued practice of CRP among pre-service and in-service mathematics teachers?

Frameworks

Theoretical Framework: CRP

CRP is a teaching framework that supports students' learning by connecting the curriculum to cultural, political, and social areas of their lives. Ladson-Billings (1995) defined CRP with three core tenets: (1) student achievement, (2) cultural competence, and (3) critical consciousness. Culturally relevant teachers have high expectations for their students' academic achievement, rather than teaching from a deficit perspective (Ladson-Billings, 1997). A culturally relevant teacher must have knowledge about their students' culture and the context of their environments (Tate, 1995). Finally, teachers empower their students to address social inequities in their schools and communities through classroom activities.

In the mathematics classroom, this framework transforms the curriculum by incorporating problem-solving topics that interest students and therefore increases engagement and understanding of mathematical concepts (Tate, 1995). Teachers can create activities and projects that integrate cultural traditions, social justice issues, and family or community experiences (Brown et al., 2019). Instruction that reflects students' culture in these ways can improve mathematics education outcomes in urban schools by showing students the importance and relevancy of their culture in STEM (Enyedy & Mukhopadhyay, 2007).

CRP offers a culture-centered approach for teachers to make connections between students' backgrounds and their mathematics learning (Tate, 1995). This powerful combination of student experience and mathematics knowledge allows students to use mathematics to address issues that are relevant to themselves and their communities (Hubert, 2014). Thus, it is critical to the state of mathematics education for our teachers to be well-trained in CRP.

Methodological Framework: Systematic Review

A systematic review is a methodological research process that uses clear, systematic methods to synthesize findings across multiple studies in an effort to address a necessary question or problem in the current research (Page et al., 2021). A systematic review can serve many roles beyond what a single study would be able to accomplish. Systematic reviews allow researchers to summarize past work that has been done in a field in order to identify patterns of phenomena among the current research, explain theories and trends from the compiled data, and identify problems that can be addressed in future studies (Page et al., 2021).

Systematic reviews are useful in the field of research because they provide deeper insights about a greater body of knowledge. In the field of educational research, in-depth case studies are often used in order to analyze behavior patterns of teachers and students, however these studies are limited to a small number of participants due to the immense amount of qualitative data. Thus, most data from these studies are not generalizable. A systematic review offers a way to generate theories and generalize trends that have been found across multiple studies focused on the same problem.

The purpose of the systematic review in this study is to synthesize papers that investigated the delivery of CRP instruction to pre-service and in-service mathematics teachers. At the time of writing, a systematic review of this specific topic was not found to be published, and this is likely due to the limited research base on CRP in mathematics teacher education. Through this systematic review of CRP literature in mathematics teacher education, strengths and weaknesses are summarized for the purpose of guiding teacher educators in the development of quality professional development.

Methods

Data Collection

Seven discrete steps were followed for this systematic review: (1) identify specific research questions based on the background of the current problem, (2) develop inclusion and exclusion criteria to identify studies related to the

research questions, (3) conduct a comprehensive database search with specified terms, (4) select initial studies in accordance with inclusion and exclusion criteria, (5) appraise the selected studies against a rubric aligned with the research questions, (6) code the data of qualified studies, (7) synthesize and present findings.

The research questions outlined in the beginning of this paper served as a guideline to construct inclusion and exclusion criteria in order to maintain a clear focus in the selection of studies for the systematic review. The inclusion and exclusion criteria are displayed in Table 1.

Table 1

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
<ul style="list-style-type: none"> • Culturally Responsive Teaching • CRP 	<ul style="list-style-type: none"> • Not focused on Culturally Responsive Teaching or CRP
<ul style="list-style-type: none"> • Preservice Mathematics Teachers • In-service Mathematics Teachers • Mathematics Teacher Educators 	<ul style="list-style-type: none"> • Pre-K-12 Students • Non-mathematics teachers
<ul style="list-style-type: none"> • Within United States • Published in English 	<ul style="list-style-type: none"> • Outside the United States • Published in a language other than English
<ul style="list-style-type: none"> • Empirical studies • Published in scholarly journals 	<ul style="list-style-type: none"> • Literature Reviews • Dissertations • Book chapters
<ul style="list-style-type: none"> • Published between 2000 – 2022 • Peer Reviewed 	<ul style="list-style-type: none"> • Published before 2000 or after 2022 • Non-peer reviewed

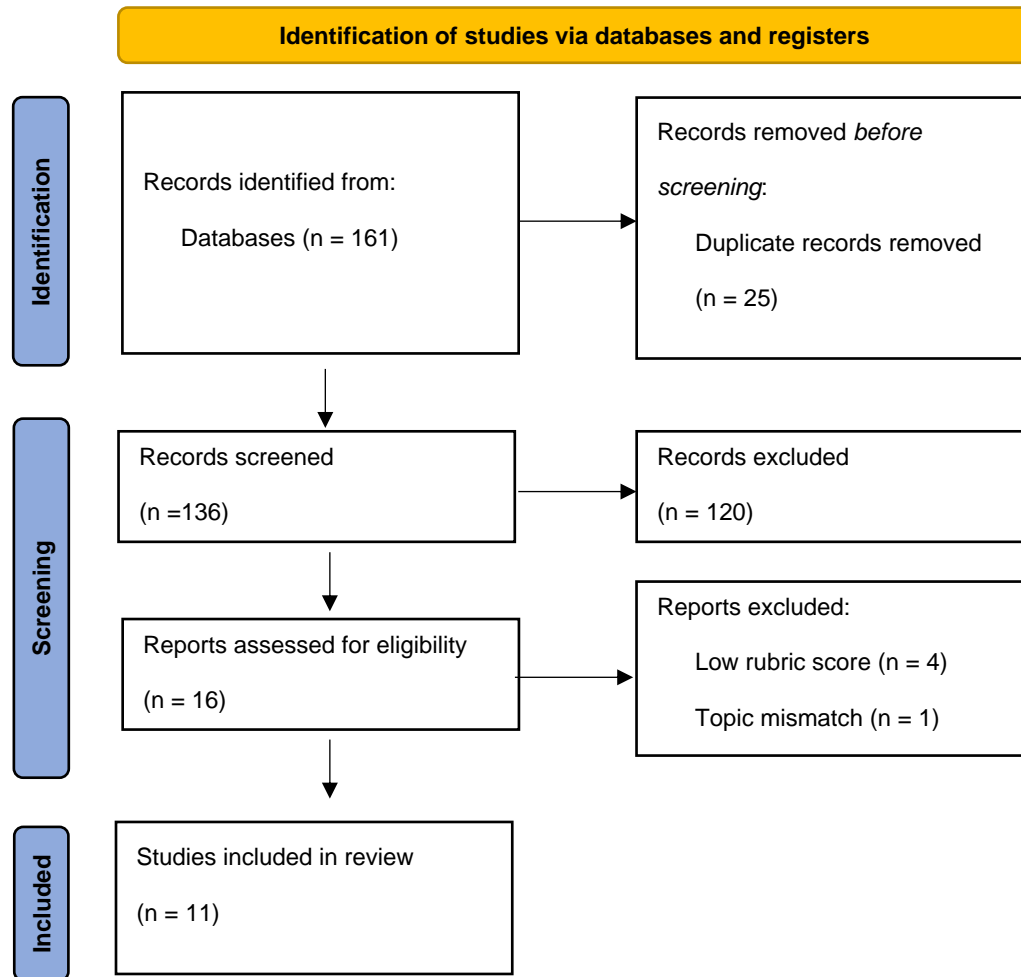
All papers focused on the instruction of CRP theories, frameworks, and practices in mathematics teacher education within the United States. Some papers also refer to a component of CRP as Culturally Responsive Teaching so this phrase was included in the search terms. The search terms were used with Boolean phrasing as follows: culturally responsive teaching AND mathematics teacher education, OR culturally relevant pedagogy AND mathematics teacher education. Subject term searches were conducted within EBSCO and JSTOR databases. The filters listed in Table 1 were applied to ensure that the articles selected were peer reviewed, published within the given timeline, and matched the desired source type as scholarly journals.

Figure 1 displays the flowchart for the article selection process. The initial search produced 161 articles. Twenty-five duplicates were removed, leaving 136 documents for screening. The remaining 136 articles were validated against topic and population criteria first based on the title, then abstract and keywords, and finally the full manuscript. Based on the title, articles were included if they mentioned “mathematics” or “STEM”, since STEM includes mathematics. However, articles were excluded if the title only mentioned science. Next, the abstracts were

screened for a population focus on pre-service and in-service teachers. If the population being studied was mathematics students, then the article was excluded. Literature reviews and research syntheses were also removed at this stage.

Figure 1

Article Selection Flowchart



After screening articles based on title and abstract, 16 articles remained for full manuscript appraisal. The appraisal rubric was designed by the author to ensure that articles met the eligibility criteria and were of a high enough quality to properly address the research questions. Two researchers independently read through all 16 articles and rated each one according to the appraisal rubric shown in Figure 2.

Both researchers met to discuss the rubric scores at length until arriving at a consensus for each of the selected articles. Trustworthiness and bias reduction were established by the consensus between the researchers. Based on the evaluation of the included literature using the rubric, four articles received a final score below 10 points (out of 15 points total) and were removed from the review. These articles were removed to establish rigor among the selected

studies, as only those studies with adequate design and presentation of results were included in the systematic review.

Figure 2

Appraisal Rubric

Criteria	Low (1)	Moderate (2)	High (3)	Notes
Topic	The article addresses only one component of Ladson-Billings' (1995) CRP Framework: (1) Student Achievement, (2) Cultural Competence, and (3) Critical Consciousness	The article addresses two components of Ladson-Billings' (1995) CRP Framework: (1) Student Achievement, (2) Cultural Competence, and (3) Critical Consciousness	The article addresses all three components of Ladson-Billings' (1995) CRP Framework: (1) Student Achievement, (2) Cultural Competence, and (3) Critical Consciousness	
Population	Pre-Service and/or In-Service Teachers STEM Teachers, no clear focus on math.	Pre-Service and/or In-Service STEM Teachers, but there is still a focus on math.	Pre-Service and/or In-Service Mathematics Teachers with a strong focus on math.	
Treatment	Professional development training/course instruction methods are not described at all.	Sample receives professional development training/course on CRP/CRT. Instructional methods are noted but not clearly described.	Sample receives professional development training or a course focused on CRP/CRT. The instruction methods used are clearly described.	
Findings	The study fails to identify whether the training/course was effective or not.	The study discusses the overall effectiveness of the training/course without focusing on specific methods.	The study discusses the effectiveness of each instructional method used in the training/course.	
Time	Less than a month	1-12 months	More than a year	
Article Title:	Appraised by:		Total Points:	

Note: Rubric used to assess articles for inclusion in the systematic review.

In addition, one article was removed after deliberations amongst the researchers because the focus of the study did not match that of the review. This was important to ensure that the information from the articles would answer the research questions presented in this paper. Thus, 11 studies were deemed sufficient for inclusion in the review. The 11 articles are marked with an asterisk (*) in the reference section of this paper.

Data Analysis

After the appraisal process was completed, the selected articles were coded within three categories based on the research questions of this paper. The 11 selected articles were read and re-read to identify codes and emerging themes. A second researcher reviewed the coded data to establish credibility. The coding process varied depending on the research question category, which is outlined below.

Research Question 1: In what ways do mathematics teachers apply CRP after receiving training from a course or professional development program?

Using a priori codes, Ladson-Billings' (1995) CRP tenets were used to label how the studies addressed and how study participants used (or failed to use) CRP in their practice. Evidence from teacher work samples were coded as "student achievement", "cultural competence", or "critical consciousness". For example, the use of rigorous mathematical tasks would be coded as "student achievement", an assumption about students' cultural backgrounds would be coded as "cultural competence", and an activity that uses mathematics to uncover social inequities would be coded as "critical consciousness".

Research Question 2: How do teacher educators instruct teachers about CRP in mathematics teacher preparation?

Using an open coding process, the researcher identified instructional methods that teacher educators used within the included studies to deliver CRP training. For example, some of the initial codes included “self-reflection”, “readings”, “lesson studies”, and “internships”. When a study presented a form of instructional activity that did not match the current codes then a new code was created. This process continued until saturation was reached. The coded data was reviewed once more to collapse codes, ensuring that they were distinct enough from other codes yet broad enough to contain sub-codes. In the end, eight distinct codes remained: self-reflection, lesson studies, readings, discussions, modeling, tools, lectures, and applications.

Research Question 3: Which teaching strategies are most successful for the continued practice of CRP among pre-service and in-service mathematics teachers?

Statements from the articles were coded as “Effective”, “Ineffective”, or “Mixed Results”, based on the original authors' findings. For example, the statement, “the CRMT tool enabled teachers to engage in systematic analysis and critique of mathematics lessons” would be coded as “Effective” (Aguirre & Zavala, 2013, p. 173). Phrases such as “there was evidence indicating limited success” were coded as “Mixed Results” as well as cases of differing results among teacher participants (Mark & Id-Deen, 2022, p. 734). Quotes from the studies were coded as “ineffective” if researchers indicated that teachers did not meet the goals of the provided professional development. For example, Herner-Patnode and Lee (2021) observed “disconnects in PTs' understanding of their classroom context, planning lessons, and reflecting on their teaching practice” (p. 19). The original author's tone and opinion on the effectiveness of their study was retained as much as possible in order to maintain data integrity.

Results

Research Question 1: In what ways do mathematics teachers apply CRP after receiving training from a course or professional development program?

Ladson-Billings (1995) outlined three tenets of CRP that have formed the foundation of instruction, evaluation, and the development of culturally relevant mathematics. In this systematic review, these three tenets served as codes that worked to categorize teacher responses, lesson plans, and reflections about CRP in mathematics. All selected studies, except for one, touched on each component of the CRP framework: (1) student achievement, (2) cultural competence, and (3) critical consciousness, and the exception article did not discuss student achievement in the analysis of teachers' growth in CRP.

Student Achievement

In the articles reviewed for this study, teachers' quotes and artifacts described by the authors were analyzed for evidence of teachers' high expectations through lesson planning decisions, attitudes displayed through teacher-student interactions, and strategies used to improve students' understanding of mathematics content. In the selected studies, teachers applied the student achievement component of CRP by using mathematical investigations in their

lesson planning to engage students in rigorous mathematics discussions that supported students' construction of learning. This is in contrast to the traditional mathematics classroom where teachers talk and provide instruction while students sit quietly and listen, which conveys the message that students have no contribution to offer to mathematics learning.

Teachers can also communicate high expectations for students through higher-order questioning that engages students in deep thinking about mathematics concepts. Asking students to explain their answers or prove why their answer is correct is one way that teachers applied CRP by moving beyond simple questioning techniques. Some teachers failed to apply CRP by presenting bias in their questioning habits in the classroom. For example, in studies that focused on CRP with English Learners, there were multiple instances where English Learners were not called on to answer questions during class. In group discussions, teachers shared that they did not want to make English Learners feel uncomfortable by calling on them. This can send a message to students that some are not capable of achievement due to their linguistic backgrounds.

Cultural Competence

Cultural competence refers to teachers' knowledge about students' cultures, languages, and interests and the ways that teachers incorporate this knowledge into mathematics learning. Teachers display cultural competence through activities and projects that integrate cultural traditions, family dynamics, or community experiences. Teachers that are culturally competent present and create problem-solving topics that interest students, which increases engagement and understanding of mathematical concepts.

In the selected studies, teachers used surveys, classroom discussions, community walks, and investigations to learn more about their students. This knowledge is valuable as a first step in guiding teachers to become more connected and aware of students' experiences as well as the local community which they come from. Teachers in Aguirre and Zavala's (2013) study identified two sources of community to draw from: school communities and home communities. The teachers who chose to use school communities created lessons surrounding sports and other school activities, while teachers who focused on home communities used topics such as food, language, and family. More successful teachers used topics that connected to students' lived experiences in a meaningful way, such as the school-to-prison pipeline and high school dropout rates. Teachers were able to apply these topics to mathematical concepts like graphing, analysis, and binomial distributions. By using topics that infuse race and culture, teachers are able to address important social issues while also showing students that mathematics has a real connection to their lives.

Critical Consciousness

The third tenet of Ladson-Billings' (1995) CRP framework is critical consciousness, which can be described as the teacher's awareness of social justice issues and willingness to act as an agent of change. Critical consciousness appeared to be most difficult for elementary teachers due to their beliefs about children's readiness for such topics.

Teachers were hesitant to address issues that were deemed inappropriate for students' age or developmental stage. However, elementary teachers in Leonard and Moore's (2014) study were able to present social justice issues to elementary students through topics such as grocery store prices, high school dropout rates, and state budgets. Thus, age is not a defining factor in the application of social justice ideas in the mathematics classroom, rather it is about changing teacher beliefs toward finding what will be most relatable and meaningful for students.

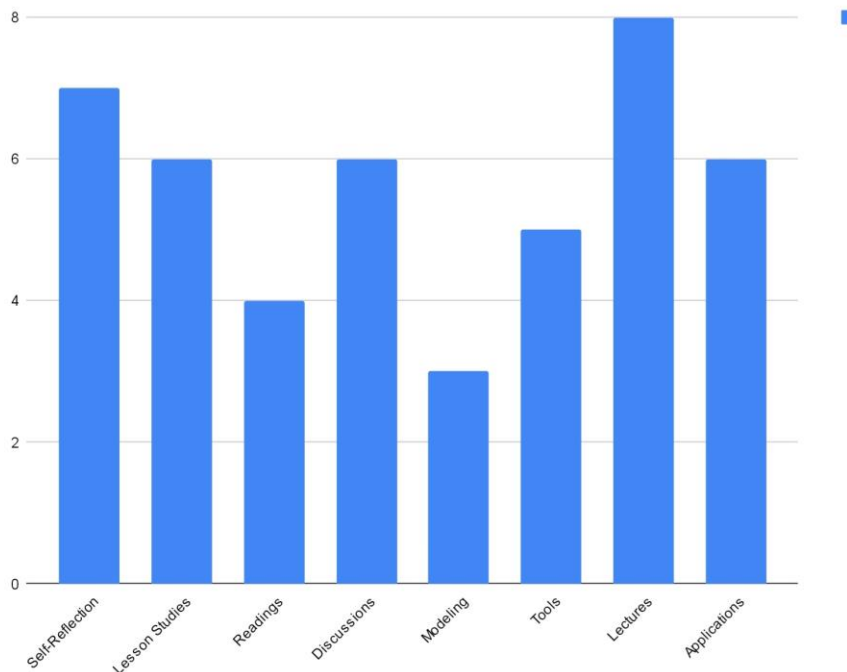
In Ramsay-Jordan's (2021) study of secondary mathematics pre-service teachers, participants were able to provide instruction that empowered students to examine health conditions in their communities. In contrast, Rubel (2017) observed teachers missing opportunities for social justice mathematics lessons because their privileged experiences had blinded them from the realities of their students. Thus, it is apparent that while teachers may attempt to apply CRP with the best intentions, they may not always be successful in accomplishing the intended goal.

Research Question 2: How do teacher educators instruct teachers about CRP in mathematics teacher preparation?

The studies reviewed in this paper used a variety of instructional methods to deliver key information about CRP to in-service and preservice teachers. The most frequently used technique was lecture-based instruction (eight out of 11 studies) and the least used technique was instructor modeling of CRP (three out of 11 studies). All frequencies are displayed in Figure 3.

Figure 3

Instructional Method Frequency Graph



Note. The number of studies that listed the given technique as an instructional method.

Traditional instruction methods such as lectures, readings, and writing assignments were the most common techniques used by the researchers and instructors involved in the selected studies, which is typical of most teacher education programs. These offer a straightforward and uncomplicated path to transfer information and knowledge to students. In this review, the studies that were most effective in improving teachers' beliefs and use of CRP were those that enhanced reading assignments and lectures through peer discussions.

Lesson studies include active and passive roles for the student teacher. In an active role, the teacher plans lesson(s) using CRP, delivers the lesson(s), then reflects or discusses the outcome with others, such as an instructor, supervisor, or colleague. In some cases where pre-service teachers do not have access to a classroom, they may only be able to complete the planning stage, or they may present their lesson(s) to a class of their peers. Alternatively, in a passive role, the teacher observes lessons, either in person, through video, or in a mock teaching demonstration, and reflects upon or critiques the use of CRP. For example, Aguirre and Zavala (2013) developed a CRP lesson analysis tool which teachers used to rate and record evidence of CRP components in others' lessons and eventually in their own lessons. Brown and Crippen (2016) also used a tool called the Growing Awareness Inventory (GAIn) to scaffold teachers' awareness and attention to CRP components in lesson planning and observations.

Many of the studies reviewed in this paper realized that teachers in their studies could have benefited from more modeling of CRP techniques and more opportunities to try out those techniques themselves. Teachers need to observe professional modeling of concrete examples of CRP specifically in their content area. When Mark and Id-Deen (2022) modeled specific instructional methods, such as arts integration and manipulatives, teachers were able to apply those methods in their own lesson planning. Modeling of specific strategies increase the likelihood that teachers will adopt the strategies in their own classrooms.

Tools, such as precise examples, activities, strategies, and rubric guidelines, were reported by teachers as extremely helpful as it gave teachers something immediate to take away and implement in their classrooms (Timmons-Brown & Warner, 2016). For example, Hudley and Mallinson (2017) provided teachers with a wait-time strategy to allow more opportunities for culturally and linguistically diverse students to participate in mathematics discussions and activities. Rubel (2017) shared examples, resources, activities, and lesson ideas from the book *Rethinking Mathematics: Teaching Mathematics for Social Justice* (Gutstein & Peterson, 2005). Song and Coppersmith (2020) introduced tools such as inquiry-based teaching methods, hands-on activities, collaborative learning strategies, and alternative assessments that urban teachers were able to use immediately in their classrooms.

Allowing teachers to apply what they have learned greatly increases the likelihood that CRP practices will continue after the course or training has ended as it links conceptual knowledge to actual practice. Applications of CRP are most often done in an internship, student teaching, or alternative certification pathways where teachers have access to a classroom setting. In programs where participants did not have access to a classroom the instructors were able to adapt by conducting mock lessons. Leonard and Moore (2014) called them "microteaching episodes", where

teachers paired up, prepared social justice mathematics lessons, then presented the lessons to peers. The variety of teaching methods in the selected studies offers a valuable opportunity to evaluate their effectiveness in achieving the intended outcomes.

Research Question 3: Which teaching strategies are most successful for the continued practice of CRP among pre-service and in-service mathematics teachers?

All studies included in this review had mixed results. It was extremely rare for teachers to display evidence of all three tenets of CRP: student achievement, cultural competence, and critical consciousness. Most teachers successfully incorporated one or two of these components but lacked in the other components, which resulted in many cases of “mixed results”. Table 2 displays excerpts from the included studies to provide examples of successful and unsuccessful cases within each tenet of CRP.

Table 2

Examples of Successful and Unsuccessful Cases from Selected Studies

CRP Tenet	Successful	Unsuccessful
Student Achievement	"Tracy's lessons were typically organized around whole-class discussions that were layered around various types of individual or group-focused investigations, involving rigorous mathematical activity around high demand tasks and with supporting tools" (Rubel, 2017, p. 85).	"Mr. Mack did not show differentiated teaching strategies for ELs to improve their mathematics learning. Most of the students who were asked for answers were non-ELs" (Song & Coppersmith, 2020, p. 76).
Cultural Competence	"The issue of rising gas price, access to transportation, opportunity to get higher education, dropout rates, and even grocery price difference between shops can be related to culture and social justice" (Leonard & Moore, 2014, p. 87).	"These are examples of cultural backgrounds and practices of the students and informs me of their current interests. Many of the graphs I used in the unit involved food..." (Herner-Patnode & Lee, 2021, p. 17).
Critical Consciousness	"Ellen framed her mathematics unit on a larger social issue of systemic racism, specifically the school-to-prison pipeline" (Mark & Id-Deen, 2022, p. 738).	"I think that it is difficult to relate math to political or social issues unless you are learning about statistics" (Ramsay-Jordan, 2021, p. 1006).

Teachers were able to design rigorous CRP activities that addressed the appropriate standards when provided with rubric tools that clearly identified student achievement as a success criterion. In addition, lesson studies helped teachers discover examples of detailed lesson plans that incorporated state standards into a cultural context. Microteaching episodes were found to be highly successful in fostering CRP traits such as using students' prior

knowledge and addressing inequity through mathematics. These cases also appear to have been successful due to the combination of collaboration with peers, the application of CRP in the development of lesson plans, and reflection about CRP beliefs in mathematics.

The third component, critical consciousness, was difficult for teachers to apply largely due to their own personal beliefs about the relevance between mathematics and social justice. The selected studies revealed that the most successful method to address this issue among teachers was structured self-reflection and small group discussions. For example, teacher educators were able to shift teachers' beliefs from a deficit perspective to an asset-based perspective in Hudley and Mallinson's (2017) study through frequent group discussions centered on linguistic differences among students.

In some cases, such as virtual learning environments, group discussions are not always the most feasible option. In the study by I et al. (2020), the instructors were able to shift teachers' beliefs about emergent bilinguals through an online course in which teachers learned about sociopolitical consciousness through lectures in video format. Other studies introduced strategies that teachers were able to use to promote student participation such as classroom discussions, grouping, and partner talk. These strategies create a more student-centered classroom environment and convey a standard of high expectations for student achievement.

Successful professional development courses scaffolded teachers' learning through multiple phases to move teachers from theoretical knowledge to active application. Through rating tools such as rubrics, teachers were able to familiarize themselves with the CRP tenets, observe and critique lessons, and eventually self-evaluate their own CRP lesson planning and delivery (Aguirre & Zavala, 2013). Success was also highly dependent on teachers' collaboration within the course. Many studies enhanced the rubric tools with group or partner discussion, allowing teachers to offer constructive criticism to one another, share challenges and ideas with one another, as well as talk through difficult topics such as race and politics.

Discussion

All the studies included in this review had mixed results from their professional development surrounding CRP. The results indicated that most teachers were not able to successfully apply CRP in their lesson planning, philosophy of teaching, or instructional delivery even after receiving professional development or university coursework on CRP. The variety of methods that the researchers used in their studies to train teachers in CRP were effective for some areas of CRP and ineffective for others. Thus, a robust combination of teaching methods is needed in the instruction and preparation of culturally relevant mathematics teachers.

The first tenet of CRP, student achievement, can be evaluated through teachers' reflections about students' abilities and through their lesson planning decisions. The studies reviewed in this paper show that teachers can shift their expectations of students from diverse backgrounds after they receive adequate training in strategies, supports, and

theoretical information regarding the positive impact of high expectations. When teachers communicate high standards it not only increases the quality of instruction but also increases students' confidence and beliefs in their own abilities. Teaching then becomes an avenue to empower students to reach their full potential, rather than limiting them to low expectations.

Despite its importance, however, student achievement was the only tenet that was not displayed by all studies, which may mean that teachers and teacher educators struggled to apply this component in their instruction. This proved to be difficult for teachers because when incorporating culturally relevant material, teachers lost the rigor of their traditional content. Those who were able to maintain high rigor, often lost the cultural and sociopolitical components. Culturally relevant activities and rigorous mathematical activities appear to be mutually exclusive to teachers. This causes teachers to feel as though they have to make a choice between one or the other. However, true CRP requires both high expectations for student achievement in mathematics and cultural relevance in mathematics applications.

Teaching methods that were effective in creating a high standard for student achievement include reading articles or book chapters that focus on the impact of high expectations in mathematics, self-reflections, and lesson studies. Teachers should first be exposed to the data and research that reveal the inequities between the expectations held for students of color versus White students and how that contributes to the achievement gap between them. Reading about case studies from other schools or classrooms can inspire teachers to understand that their expectations for students have a direct impact on their performance, regardless of labels that may have already been placed on students deemed as “below grade level” or “remedial”.

After reading, teachers could be directed to self-reflect on what expectations they currently hold or have held in the past. Many teachers may believe that they are not part of the problem that they have read about. This is why it is necessary to provide ample opportunities for self-reflection in an environment that prompts honesty and removes any fear of judgement. When designed appropriately, class discussions can offer a safe space for teachers to share fears, ideas, challenges, and successes that they have had with CRP. Multiple studies recommended that teachers participate in lesson analyses, critique each other's lessons, or evaluate a sample lesson provided by the instructor. By viewing others' work, teachers can gain more ideas, view problems from another perspective, and engage in critical thinking about what it means to apply CRP in mathematics lessons.

Lesson studies give teachers a concrete application for what they have read and written about. Without an example that directly relates to the topic, there is the danger that what teachers have learned will remain theoretical or philosophical in nature. They may change their beliefs and understand that it is important to hold high expectations for all students, but they may not know what that looks like in the classroom. Lesson planning is the foundational step to setting up high expectations for student achievement. The selection of tasks and activities that students engage in can range from challenging with high cognitive demand to simple procedure-based tasks with low

cognitive demand (I et al., 2020). Teacher educators can assist teachers to develop stronger lesson plans by providing examples of activities that they can easily replicate or modify to fit their school's cultural context, their mathematical subject, and their students' level of rigor.

The second tent of CRP, cultural competence, can be evaluated through teachers' lesson plans and writing responses. Teachers in the selected studies displayed evidence of cultural competence by creating lesson plans that incorporated students' culture. Successful teachers chose topics that were meaningful and relevant for students. Moderately successful teachers chose topics that were superficial, but still relevant for students. Unsuccessful teachers continued to use assignments that lacked any relevance or even chose topics that revealed a stereotypical bias towards students' culture. Most teachers in the selected studies were moderately successful, however there were outliers at each end of the spectrum as well.

Teachers in the selected studies struggled to identify the appropriate cultures and communities to draw knowledge from. For example, teachers chose to draw cultural knowledge from school communities like sports or general life experiences like budgeting, without addressing the specific cultures and experiences of the students in the class. Teachers need more personalized training about how to appropriately learn about students' cultures and integrate it fully into the curriculum. Hudley and Mallinson (2017) used an online survey to give their participants a voice on what they felt they would benefit from in the professional development sessions. The instructors then structured the sessions around what participants requested to learn about. This simple step created more buy-in from the teachers, more rich discussions during the sessions, and more opportunities for immediate and direct applications of the content.

Self-reflections and discussions offer an opportunity for teachers to grapple with their teaching philosophy, but it does not always lead to considerable change. When attempting to develop cultural competence, some teachers made assumptions about children's home lives or their experiences without getting to know their students. For example, teachers associated family's socioeconomic status with the amount of academic help that a student would receive at home (Herner-Patnode & Lee, 2021). In Ramsay-Jordan's (2021) study, teachers' reflections displayed evidence of prejudice reduction, but their lesson evaluations lacked proper enactment of CRP due to fear, discomfort, and lack of strategies. Thus, teachers' awareness or knowledge does not automatically translate into appropriate action.

Teachers should first acquire knowledge about their students' culture to make learning relevant and appropriate. This is often the greatest challenge that teachers face when growing cultural competence because they lack the resources and strategies to gain knowledge about students to make learning relevant. Additionally, cultural differences can make some teachers feel uncomfortable due to lack of experience in diverse contexts. Effective teacher preparation programs provide opportunities for teachers to grapple with this discomfort in situations where they can learn about their students' experiences such as community walks, student investigations, and presentations from community members.

These are necessary learning experiences for teachers, as Herner-Patnode and Lee (2021) found that the pre-service teachers in their study had “a narrow interpretation of students' cultural backgrounds” (p. 16). Some of the teachers in their study used surveys and online demographic data to find background information about their students, but failed to apply the information in a meaningful way in their lesson planning. Instead, the teachers used general concepts such as food, money, and sports to connect with students’ experiences. Thus, teacher educators need to ensure that they clearly define cultural competence so that teachers can move beyond the simplistic, superficial, stereotypical view of students' cultures.

Reflection throughout lesson planning is key to ensure that students' culture is being accurately represented in the content. This requires work on the teacher's end both before and after a lesson. First, the teacher should do research about students' interests and cultures, being careful not to make assumptions about what students experience outside of school. After the lesson, the teacher should reflect upon students' responsiveness to the instruction. A culturally competent teacher is constantly learning and reflecting on students' backgrounds, recognizing that not all students share the same experiences.

Teacher educators can support teachers in this endeavor by engaging them in critical reflection about biases, power and privilege. Direct modeling of proper reflection techniques may be necessary to break down the walls that exist surrounding these topics. Some of the studies used rubrics that prompted teachers to self-reflect about their lesson plans or observed lessons given by other teachers. These structured reflections prompted teachers to learn about what to look for in CRP and how to evaluate themselves, which is a skill they can continue to use throughout their teaching career.

The third tenet, critical consciousness, can be observed through teachers’ lesson plans, written reflections, and the way they interact within their classroom and school community. CRP is a vessel for social justice, creating radical change within the education system. Teachers who use their position to make students aware of social injustices and provide problem-solving opportunities to address those injustices have critical consciousness built into their pedagogy.

Teachers in the selected studies who displayed evidence of critical consciousness developed lessons that surrounded important social justice issues such as the school-to-prison pipeline, redlining in school districts, and availability of fresh food to neighborhoods in their cities. Teachers who did not display critical consciousness developed lessons that surrounded superficial topics such as shoes, going to the grocery store, or other word problems that are commonly found in textbooks. In addition, some of their written reflections and group discussions revealed biases or stereotypes held against their students.

Reading assignments can help teachers learn about the social injustices that are present in education and other areas of society that are relevant to students. The first step to breaking down stereotypes is awareness and exposure to the

lived realities of marginalized individuals. Teacher educators should carefully select articles that highlight systemic racism in education and the dangers of stereotypes in education.

Lesson studies can provide examples of social justice issues that are directly linked to mathematics. It can be difficult for teachers to come up with these ideas on their own, especially if they have little knowledge about these issues. Teacher educators can also provide resources, such as journals, magazines, or websites that showcase lessons with critical consciousness. Then, teachers can take what they have learned beyond the classroom by continuing to stay informed on new topics.

The studies selected for this review provided a variety of teaching methods and suggestions for teacher educators to improve outcomes in CRP instruction. By evaluating the successes and failures of these previous studies, teacher educators can see which techniques are the most effective for each intended goal. Based on the studies reviewed here, the recommended instructional methods for CRP courses include reading about background knowledge of CRP, self-reflecting over biases, and examining lesson studies.

Conclusion and Limitations

The successes and failures of teachers, teacher educators, and researchers provide an opportunity for others to learn from. In responding to the research questions through investigation using a systematic review, it was found that none of the studies were completely successful in training culturally responsive teachers to use all three core tenets of Ladson-Billings' (1995) CRP framework. Each study used a unique combination of teaching methods, which allowed for a comprehensive review of which strategies applied best to each tenet of CRP.

Teachers applied what they learned from professional development or CRP courses in various ways, including lesson plans, self-reflections, and delivery of culturally relevant mathematics instruction. Most teachers in the studies were moderately successful, meaning that they were able to apply one or two of the CRP components, but not all three. In other cases, teachers were successful in applying CRP components to one area of their pedagogy, but not all areas. For example, some teachers were able to improve their mindset about student achievement, but they failed to develop high-demand tasks that were culturally relevant. This shows that there is a gap between theoretical and practical knowledge.

The methods that the studies used to transfer this knowledge to teachers included lesson studies, self-reflections, readings, discussions, lectures, providing tools, internships, and modeling. The most effective methods identified in this review were lesson studies, self-reflections, and modeling. However, not all studies used these methods or used a different combination of methods, so the current data is limited.

Three of the 11 studies reported that modeling would be necessary to improve their training of mathematics educators. However, only one study actually used modeling in their CRP professional development (Mark & Id-

Deen, 2022). The teachers in this study were able to construct in-depth, highly rigorous mathematics lessons that addressed important social justice issues. Based on this study, modeling appears to have a great impact on the success of CRP application for teachers who are learning about CRP. However, more research is needed to examine the range of benefits that modeling may offer in CRP mathematics methods courses.

Due to a limited amount of research about CRP in mathematics, selected articles included studies that involved science and mathematics teachers, STEM teachers, and elementary teachers who taught mathematics. There were not enough studies focused on CRP in secondary mathematics to form an in-depth systematic review. Thus, the results discussed in this study may not be specific enough to address issues in secondary mathematics. More research is needed in the specific area of CRP in secondary mathematics so that teacher educators can better prepare culturally relevant teachers.

This study holds significance for teacher educators who strive to create better-prepared teachers for the culturally diverse populations that they will encounter. The systematic review detailed here revealed that teachers struggle with each tenet in different ways, which means that teacher educators should use a variety of instructional methods to fully address each tenet. Based on the findings of these studies, the recommended approach to instructing teachers about CRP is to first assess biases through reflection and discussion in a safe space, then explore diverse cultural backgrounds and communities through activities and investigations, and lastly provide modeling of equitable teaching techniques that incorporate social justice and cultural contexts into lesson planning.

For researchers in education, more work can be done that is focused on teacher education and preparation in CRP for mathematics. Developing programs that follow the recommendations above, then assessing the effectiveness of those recommendations through a rubric such as the one developed by Aguirre and Zavala (2013), would provide more direction for future courses that address CRP in mathematics. This may take years to develop, implement, and assess long-term outcomes for CRP application in mathematics classrooms. However, with each step that is taken, mathematics education is becoming a more equitable place for all learners.

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