



Culturally Responsive Mathematics Teaching: A Research Synthesis

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Abstract

The purpose of this article is to synthesize empirical research conducted on culturally responsive mathematics teaching (CRMT) with culturally and linguistically diverse (CLD) learners. Thirty-five published studies between 1993 and 2018 met the criteria for inclusion in this review. Criteria included: (a) the study was published in a peer-reviewed journal, (b) the study was conducted within a K-12 U.S. public school context with practicing teachers, (c) culturally responsive teaching or culturally relevant pedagogy was part of the study's theoretical framework, and (d) information about methods was reported. Findings reveal the value of CRMT in fostering equitable and inclusive mathematics learning environments. More research on CRMT with CLD students in school settings is warranted. Implications for policy, practice, and research are discussed.

Keywords Culturally and linguistically diverse (CLD) learners · Culturally responsive mathematics teaching (CRMT) · Synthesis research

Introduction

Evidence-based research over the past decade has focused on improving student mathematics skills (Rittle-Johnson and Jordan 2016). This mathematics research is the basis for instruction in critical foundation skills and problem solving. Historically, the “achievement gap” has served as the primary impetus for advancing mathematics proficiency among culturally and linguistically diverse learners (CLD) from marginalized groups (Gutiérrez and Dixon-Román 2011). The most recent data from the National Assessment of Educational Progress (NAEP; National Center

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for Education Statistics 2017) show that 51% of White students scored at or above proficiency in the fourth grade, whereas an average of 22.5% of African American, American Indian/Alaska Natives, and Latino/a students scored proficient in the fourth grade. Across these CLD subgroups, proficiency percentages decreased by an average of 16.5% in grade eight and by an average of 9% in grade 12 (NAEP 2017). However, the emphasis on academic achievement has overshadowed the necessity to investigate school experiences (e.g., teacher expectations, challenging classes, rapport with teachers, parental involvement) as factors that may contribute to mathematics success (Berry 2008; Stinson 2006). A focus on the context of learning mathematics can provide teachers and researchers with a better understanding of the educational environments that produce successful outcomes for students (Gutiérrez 2008). Culturally responsive mathematics teaching (CRMT) provides this context within an equitable framework for mathematics instruction (Celedón-Pattichis et al. 2018).

The Challenge

Culturally responsive research that addresses mathematics instruction with CLD students has been investigated since the 1990s (Inglis and Foster 2018). However, its application across schools and classrooms is still emerging (Khalifa et al. 2016; Sleeter 2012). A major reason for the slow development of culturally responsive practice in mathematics has been the political nature of education (Sleeter 2012). Despite reform agendas calling for the improvement of mathematics education for all students, traditional approaches to instruction in favor of basic skills instruction continue to dominate practice (Ellis and Berry 2005). The majority of mathematics education in the U.S. is based on standardized curricula, pedagogy, and testing that is not normed on CLD students (Bartell et al. 2017; Kress 2005). This one-size-fits-all approach separates students' cultural strengths and experiences from teaching and learning mathematics, which influences their response to mathematics instruction (Leonard 2008).

Furthermore, the impetus among education policymakers to identify scientific-based knowledge (e.g., What Works Clearinghouse, WWC) that emphasizes teaching basic skills independent of CLD learners' sociocultural experiences is based on the assumption that these pedagogical practices would improve their mathematics achievement (Bullock 2012). As an example, Slavin (2008) upholds positivism (i.e., objectivist knowledge) in education research by privileging evidence-based practice. That is, positivist theory discounts subjective interpretations of reality (Denzin and Lincoln 2018), and this may be problematic because CLD students' lived experiences (i.e., sociocultural knowledge) should be considered when designing learning environments. This sociocultural knowledge (i.e., cultural and cognitive resources) that students bring to the classroom and teachers incorporate in instruction helps students make meaningful connections to new information (Orosco and O'Connor 2011). Thus, the sole emphasis on evidence-based practices without integrating CLD students' cultural and linguistic strengths has contributed to the marginalization of these students in mathematics classrooms (Sleeter 2012). In view

of this, further research is needed that describes how teachers can provide equitable mathematics instruction (i.e., CRMT) to foster learning for all students (Celedón-Pattichis et al. 2018). Although research supports the value of CRMT, more needs to be understood about how teachers can apply this approach to mathematics education in their increasingly diverse classrooms (Celedón-Pattichis et al. 2018; Leonard 2008; Nasir et al. 2008).

The authors agree with Gay (2018), Ladson-Billings (1995b), and Nieto (2010) that meeting the learning needs of students from CLD backgrounds is one of the major challenges facing today's teachers who are primarily White, middle-class, and monolingual. It is valuable for teachers to recognize that mathematics education does not occur in isolation of sociocultural context (Nasir et al. 2008). The sociocultural context is important to students' mathematical development because learning is shaped by cultural practice (Barta and Brenner 2009). As an example, many CLD students come from backgrounds that value collectivist approaches to learning, such as interdependence, cooperation, and collective problem-solving (Veléz-Ibáñez and Greenberg 2005). Conversely, they may receive mathematics instruction in schools that prioritize individualism and competition, such as direct instruction that promote a dominant society's learning patterns. However, research has shown that creating learning environments that value and incorporate students', families', and community members' cultural and linguistic strengths into instruction creates a nexus to mathematics cognition (e.g., Wenger 1998). Thus, teaching and learning practices that provide an interface between students' lived experiences and mathematics activities can play a central role in promoting mathematics comprehension.

Other indicators of student success in mathematics (e.g., instructional engagement, empowerment, critical discourse, agency) have been documented in studies on culturally responsive teaching (Aronson and Laughter 2016). This research reinforces that the positive impact of drawing on students' cultural and linguistic experiences is not exclusive to academic achievement (Aronson and Laughter 2016). Thus, mathematics teachers should recognize these and other "signs of excellence" (i.e., positive peer interactions, positive perceptions about mathematics ability) in their teaching practices to promote successful learning for all students (Gutiérrez and Dixon-Román 2011). This knowledge is key in building learning environments conducive to these and other outcomes of student success (Gutiérrez 2008).

Finally, although CLD students bring a vast array of cultural and linguistic strengths to the classroom, they are often faced with instruction that upholds the traditional view of mathematics as culture neutral (Nasir et al. 2008), deficit orientations towards diversity (Bartell 2011), and a lack of skill and experience in applying culturally responsive practices (Turner et al. 2012). Collectively, these factors present a challenge to many teachers in helping their learners make connections between mathematical knowledge and their cultural practice. More research is needed to help teachers find and recognize culturally responsive approaches that address the divide between home and school as they are essential in remedying the past ineffectiveness of mathematics education for CLD students (Ladson-Billings 1997).

For the purpose of building a knowledge base on the educational development of CLD students in mathematics, the authors conducted a synthesis to describe the

aspects of culturally responsive mathematics teaching (CRMT) that have been studied through a coherent body of descriptive methods. This synthesis builds on the core tenets of culturally relevant pedagogy (i.e., academic success, cultural competence, critical consciousness) to investigate how teachers can create equitable and successful learning experiences for all students (Ladson-Billings 1995a, b, 2006). The first tenet, academic success, focuses on student learning to promote student self-esteem and positive learning behaviors (Ladson-Billings 2006). Cultural competence, the second tenet, involves teaching practices that view students, their families, and the community as knowledgeable resources (Ladson-Billings 1995a). The third tenet, critical consciousness, focuses both on teacher awareness of social inequities and teaching practices that allow students to recognize sociopolitical issues in their society (Ladson-Billings 1995b). The following research question guided the synthesis: What is the current implementation of CRMT with CLD students?

Theoretical Framework

Culturally responsive teaching is grounded in sociocultural theory, which is based on the premise that cognitive development (i.e., mathematical development) is mediated through the use of culturally constructed practices, tools, and symbols (Vygotsky 1978). Thus, mathematical cognition is shaped through social interaction and practice which in turn facilitate mathematical development (Barta and Brenner 2009; Leonard 2008). Culture and mathematics learning are intertwined in that they are both transformed through everyday lived experiences and are shaped by those experiences (Lave 1988). This cognitive development takes place through co-structured learning occurrences with more capable others or experts (i.e. zone of proximal development; Vygotsky 1978). These experts use scaffolds or instructional supports that allow learners to use their cultural backgrounds and strengths to achieve mastery (Swain et al. 2015; Villegas and Lucas 2002).

Teachers who are culturally responsive value and incorporate culture, language, heritage and home/community experiences into mathematics instruction can improve student academic achievement (Leonard 2008; Mukhopadhyay et al. 2009). They capitalize on students' cultural and linguistic knowledge and use these strengths as a platform to foster higher-level thinking skills (Au 2006; Gay 2018; Ladson-Billings 2009; Nieto 2010). They also serve as cultural mediators by building strong and warm working relationships between school and community to advance their goal of creating culturally responsive learning environments (Martin 2006b). Therefore, CRMT makes learning more accessible, relevant, and meaningful to CLD students (Celedón-Pattichis et al. 2018; Leonard et al. 2010).

Method

The authors limited their search to research articles published in peer-reviewed journals between 1993 and 2018. They chose to begin their search in 1993 as it was shortly after Ladson-Billings (1992) published a compelling article on culturally

relevant teaching that served as a catalyst to integrate this instructional framework into K-12 learning environments. The authors systematically searched for articles using the following strategies: (a) online database searching, (b) ancestral searching, and (c) Google Scholar search. They limited the review to K-12 public school research conducted in the United States with practicing rather than preservice teachers to increase the likelihood of identifying articles representative of successful CRMT implementation. Also, the authors included studies in which culturally responsive teaching or culturally relevant pedagogy was part of the theoretical framework to secure rich description on CRMT. To ensure that the authors only included research studies, potential studies must have described their methods, including the study's setting, participants, data sources, and data collection procedures. In addition, the authors excluded studies that took place exclusively beyond regular school hours (e.g., after-school homework clubs) to focus the investigation on students' school experiences.

First, the authors conducted an exhaustive search using three online databases supported by their institution: Academic Search Complete, ERIC, and PsycINFO. These databases are commonly used among researchers to identify articles in the field of education. The authors used the following search terms: *culturally responsive teaching*, *culturally relevant pedagogy*, *culturally sustaining pedagogy*, and *mathematics*. These terms were used in combination with Boolean Operators (e.g., or, and) to identify studies for this synthesis published between 1993 and 2018. The initial search yielded 1566 results. The authors read the abstracts of all 1566 articles (473 in Academic Search Complete, 755 in ERIC, and 338 in PsycINFO) and used the inclusion criteria to screen each article. Thus, the authors excluded studies that did not involve practicing teachers or did not meet one of the other inclusion criteria (e.g., K-12 U.S. public school context, culturally responsive/relevant theoretical framework). This screening removed 1536 studies, leaving 30 articles. Another 11 articles were removed upon a further screening of the full article. The database search left 19 articles that met the inclusion criteria. An ancestral search of references from the identified articles was reviewed which yielded an additional seven articles. This brought the total number of articles found to 26. Next, the authors used Google Scholar to find studies not identified in the initial search, including studies recommended by the reviewers. Nine studies were added using this approach. A total of 35 studies met the criteria for inclusion in the synthesis.

Coding Procedures

The researchers used a combination of deductive and inductive analysis to code the data and identify themes (Lincoln and Guba 1985). Codes were iteratively refined by continually returning to the data and systematically exploring data constructs for categorization purposes. The core tenets of culturally relevant pedagogy (i.e., academic success, cultural competence, critical consciousness) served as the theoretical categories which guided the analysis through the deductive and inductive coding process. The core tenets served as a platform for analysis from which codes were established and refined to generate themes. Deductively, the researchers identified

existing theoretical categories from the literature on culturally responsive teaching or culturally relevant pedagogy (e.g., Aceves and Orosco 2014) and proceeded to confirm or support these themes from the data (Lincoln and Guba 1985). Six a priori themes that were used as codes included: (a) culture, language, and racial identity, (b) instructional engagement, (c) high expectations, (d) critical thinking, (e) multicultural awareness, and (f) social justice (Aceves and Orosco 2014). The first four preexisting themes aligned with the first tenet of culturally relevant pedagogy (i.e., academic success) and the remaining two themes aligned with the third tenet (i.e., critical consciousness). The researchers expanded or contracted codes as necessary. For example, the preexisting *Multicultural Awareness* code became the *Educator Reflection* theme to include teacher dispositions that were representative of both self-awareness/reflectiveness (i.e., thinking critically about one's and others' beliefs) and openness to diversity (Mills and Ballantyne 2010). The researchers were also open to discovering potential new themes from the data. Inductively, they looked for emerging patterns that existed in the data to include as categories or themes (Creswell 2014). A new theme that emerged inductively was initially a category called *Teachers' Positive Engagement with Family and Community*. This code became part of the more encompassing *Collaboration* theme which developed from the second tenet of culturally relevant pedagogy (i.e., cultural competence). This theme was defined to include student collaboration in the classroom (e.g., collaborative learning) and teacher collaboration.

The researchers followed several strategies (e.g., researcher discussion, cross-checking, thick description) to guide the data analysis process (Corbin and Strauss 2015). The ongoing and recursive nature of synthesis research required consistent interaction between the authors to validate themes and findings. The researchers believed that their diverse backgrounds, professional training, and perspectives on conducting synthesis research allowed for an insightful, thorough, and comprehensive analysis of the data. The first author had been a veteran teacher of CLD learners. The second author, a seasoned qualitative researcher at a major research university, brought an extensive background in culturally responsive research and teaching to this study. During their weekly meetings, the two authors shared ideas, discussed findings, and considered possible themes (Glaser and Strauss 2017). They used thick description to clearly define themes and cross-checked those definitions with the data and each other. It was through the use of these varied research strategies that the themes and conclusions of the synthesis evolved.

Interrater Reliability and Validity

Because this study followed several research methods strategies (e.g., researcher discussion, cross-checking, thick description) to improve the reliability and validity of the synthesis (Wolcott 2009), the researchers arrived at a consensus that agreement and consistency of the qualitative codes was obtained when evaluating and discussing at least 1/3 of the studies (e.g., LeCompte and Schensul 2013). A coding sheet was developed to document theme examples from each study. The interrater agreement was calculated by dividing the sum of agreements by the sum of agreements

and disagreements, then converting the result to a percentage (Miles and Huberman 1994). At the percentage of studies reviewed (34%), the interrater agreement rate on themes between the two authors was 100%.

Results

Thirty-five studies met the inclusion criteria (26 qualitative, six mixed methods, three quantitative). The studies that cited demographics included 11 African American teachers (80 African American students), 11 Latino/a teachers (75 Latino/a students), one American Indian/Alaska Native teacher, and 42 White teachers. All studies addressed the content area of mathematics (i.e., there were no studies in other domains, such as reading or science). The authors provided a summary of each study's purpose, methodology, and participants (see Table 1). Their findings are organized by the following seven themes (e.g., Aceves and Orosco 2014): cultural identity, instructional engagement, educator reflection, high expectations, student critical thinking, social justice, and collaboration.

Cultural Identity

Mathematics instruction that connects to students' cultural backgrounds shapes how they define themselves in relation to mathematics (i.e., mathematics identity). According to Martin (2000), mathematics identities encompass one's beliefs about the ability to perform mathematically which is influenced by the sociocultural context. Thus, mathematics identity is closely connected to cultural identity. Cultural identity is a concept that refers to how one identifies with a particular cultural group which evolves over time (Usborne and Taylor 2010). Students' cultural identities are shaped by their experiences and interactions within the learning context (Irizarry 2007) and are important for building personal identity, self-esteem, and well-being (Usborne and Taylor 2010). CRMT can promote positive cultural identities in CLD students by connecting learning to their knowledge and experiences in culturally affirming ways.

The teachers in many studies facilitated learning activities that valorized their students' cultural values and practices while contributing to the development of positive mathematics identities. As an example, a teacher of fifth grade Latino/a students invited family members to the classroom where they had the opportunity to interact and learn mathematics with students (Quintos and Civil 2008). During these interactions, the generative discourse between the students, family members, and the teacher validated the importance of cultural identity in performing inquiry-based problem-solving tasks. In another study, two high school teachers used cultural referents to explain concepts that connected to their students' cultural and experiential knowledge (Clark et al. 2013). For example, one teacher in the study linked the mathematical concepts of domain and range to the geography of his students' neighborhoods and home states. In the same study, another teacher emphasized how infants use algebraic reasoning when communicating their needs. These teachers

Table 1 Studies included in the review with CRMT purpose, methodology, and participant characteristics

Study	Purpose	Methodology	Participants
Tate (1995)	To explore the practices of culturally relevant pedagogy within the context of mathematics instruction for African American students	Qualitative	One female teacher of a laureate program for gifted students at a predominantly African–American middle school
Gutstein et al. (1997)	To study culturally relevant teaching and how teachers use their connections with students to build their mathematical knowledge	Qualitative	Five teachers from bilingual programs across five grades (second, third, sixth, seventh, and eighth) at an elementary and middle school with a 99% Latino population
Gutiérrez (1999)	To explore the collective practices of a high school mathematics department in advancing a large number of its Latino/a students to higher-level mathematics	Qualitative	One mathematics department of a high school with predominantly Latino/a students who has been successful in advancing its students to higher-level mathematics
Gutiérrez (2000)	To explore the contextual factors contributing to the success of one high school mathematics department in getting African American students to take advanced level mathematics courses	Qualitative	Eight math departments with one urban high school as a focal case study with a predominantly African American student population
Cahmann and Remillard (2002)	To explore the use of culturally relevant practices within a context of meaningful mathematics teaching	Qualitative	Two-third-grade teachers (one Latino female and one White female) at two urban elementary schools
Gutiérrez (2002)	To explore how effective high school mathematics teachers of Latino/a students used language to support student mathematics development	Qualitative	Three high school mathematics teachers of Latino/a students in an urban school with a predominantly Latino/a student population
Gutstein (2003)	To describe components of teaching and learning mathematics for social justice	Qualitative	One White male practitioner-researcher. Twenty-eight Latino/a students during seventh grade and eighth grade years at one elementary and middle school with a 99% Latino population
Berry (2005)	To examine the perceptions and experiences of two African American male middle school students who experienced success in mathematics	Qualitative	Two African American middle school males enrolled in Algebra I
Lipka et al. (2005)	To evaluate the effectiveness of a culturally relevant mathematics curriculum	Mixed methods	Sixth grade American Indian/Native Alaska students and two teachers (one American Indian/Native Alaskan* and another new to Alaska)

Table 1 (continued)

Study	Purpose	Methodology	Participants
Martin (2006a)	To examine how African American students and adults (e.g., parents, teachers) experience mathematics learning	Qualitative	One hundred students, parents, and community members
Berry (2008)	To examine the perceptions and experiences of African American parents and their middle school sons who experienced success in mathematics	Qualitative	Eight middle school African American males enrolled in Algebra I and their parents
Boaler (2008)	To explore how urban high school mathematics teachers promoted equitable relations among highly successful mathematics students from CLD backgrounds	Mixed methods	Approx. 700 high school mathematics students across three high schools with one diverse urban high school as a focal case study
Boaler and Staples (2008)	To investigate the equity-based teaching approaches of an urban high school with successful mathematics students from CLD backgrounds	Mixed methods	Approx. 700 high school mathematics students across three high schools with one diverse urban high school as a focal case study
Quintos and Civil (2008)	To explore the engagement of families in their children's mathematics learning	Qualitative	Eighteen fifth grade students, the parents of four of these students, and their female Latina mathematics teacher. The case study students were Latino/a
Gonzalez (2009)	To investigate mathematics teachers' beliefs about teaching mathematics for social justice and how ideas about social justice and mathematics change beliefs about teaching mathematics	Qualitative	Seven female high school female mathematics teachers (one White, two Hispanic, two African American, one mixed race, and one African)
Enyedey et al. (2011)	To describe the ways in which students engaged in an ongoing process of negotiation with their peers and teacher to select a research question during a curriculum unit on central tendency	Qualitative	Two-sixth grade classrooms with a total of 47 students
Rubel and Chu (2012)	To examine teachers' application of culturally responsive mathematics pedagogy in the first year of a professional development project	Mixed methods	Seven high school teachers (three White, one African American, two Afro-Caribbean, and one African) from two schools
Bonner and Adams (2012)	To reveal the characteristics of CRMT	Qualitative	One African American female fifth grade mathematics teacher and her fifth grade low-income African American students

Table 1 (continued)

Study	Purpose	Methodology	Participants
Cholewa et al. (2012)	To examine the relational processes of one culturally responsive mathematics teacher	Qualitative	One African American female fifth grade mathematics teacher and a class of 50 fifth grade students
Kisker et al. (2012)	To assess the effects of two culturally relevant math modules	Quantitative	Seven-hundred fifty-six second grade American Indian/Native Alaska students and sixty-seven teachers from 50 schools
Shumate et al. (2012)	To investigate the effects of the integration of culturally responsive practices in mathematics instruction on the academic achievement of Latino/a students with MD	Quantitative	Five Latino/a students with MD in an eighth grade resource room
Aguirre and Zavala (2013)	To introduce a CRMT lesson tool to teachers designed to support them to evaluate their lessons to make them more culturally responsive	Qualitative	Six beginning K-8 teachers (three elementary, two middle school, and one substitute teacher). Five teachers were White females and one teacher was a White male
Bartell (2013)	To investigate teachers' beliefs and understanding as they learn to teach mathematics for social justice	Qualitative	Eight high school mathematics teachers (four female and two male White teachers from four high schools)
Clark et al. (2013)	To explore the perspectives and practices of two African American teachers as they support their African American students' mathematics identity formation and development	Qualitative	Two African American high school mathematics teachers (one female and one male)
Gregson (2013)	To examine how a teacher teaches mathematics for social justice and navigates its challenges	Qualitative	One female eighth grade White teacher
Jackson (2013)	To report the knowledge related to equity in teaching mathematics to African American students	Qualitative	Eight elementary mathematics teachers (five White and three African American) from three school districts
Bonner (2014)	To provide insight into the culturally responsive practices of highly successful mathematics teachers of traditionally underserved students	Qualitative	Three female mathematics teachers; one African American fifth grade teacher in elementary school; one White teacher of students in sixth to eighth grade; one Mexican-Arab mathematics teacher in an all-girls middle school

Table 1 (continued)

Study	Purpose	Methodology	Participants
Hubert (2014)	To examine students' perspectives on culturally relevant mathematics instruction in relation to their participation in a culturally relevant mathematics class	Qualitative	Thirty-seven students (predominantly Hispanic and African-American) aged 16–22 years
Raygoza (2016)	To outline how critical pedagogy in the mathematics classroom can support student engagement in trans-formational resistance	Qualitative	One female White practitioner-researcher and her Latino/a students in a ninth grade Algebra I classroom
Timmons-Brown and Warner (2016)	To examine the impact of a two-day CRP workshop on mathematics teachers' perceptions and student relationships	Mixed methods	Five elementary and three middle school teachers from six schools
Corp (2017)	To examine how African American students responded to culturally responsive stories in their mathematics class	Qualitative	One female White teacher and her seventeen third grade African American students
Driver and Powell (2017)	To investigate the effects of a culturally responsive word solving intervention for ELs with MD	Quantitative	Nine third grade ELs with MD
Orosco and Abdulrahim (2017)	To support one special education elementary school teacher implement CRMT strategies with word problems for ELs with MD	Qualitative	One bilingual special education elementary school teacher and her Latino/a ELs with MD in a special education resource room setting
Parker et al. (2017)	To explore how high school mathematics teachers' perceptions about the role of culture in mathematics instruction and being culturally responsive changed as a result of their engagement in a graduate course	Qualitative	Thirteen White high school teachers (six male and seven female)
Matthews and López (2018)	To investigate the links between teacher beliefs to teacher-reported culturally responsive behaviors to predict student mathematics achievement	Mixed methods	Five teachers (grades three to five) from six elementary schools and 568 Latino/a students

CLD culturally and linguistically diverse, *CRMT* culturally responsive mathematics teaching, *MD* mathematics difficulty, *CRP* culturally relevant pedagogy, *EL* english learner

believed that making mathematics familiar to learners had a positive influence on how they perceived themselves mathematically. Additional ways teachers contributed to their students' cultural identity development included linking the concept of factoring numbers to the revered role of family or kinship within African American culture (Bonner 2014; Bonner and Adams 2012; Cholewa et al. 2012). The students in these studies were empowered to apply their sociocultural knowledge to make meaningful mathematical connections.

In two other studies (Raygoza 2016; Tate 1995), teachers prepared students to take informed action on culturally relevant projects by helping them build background knowledge in conducting research designed to transform lives. The students, who collectively identified a research topic and planned its implementation, were motivated to use higher-order mathematics skills (e.g., critically analyzing data, complex problem-solving, mathematical literacy) to achieve their action plans which helped them view themselves as capable mathematics learners. In another study, a special educator taught Latino/a students to solve word problems by linking mathematics language to everyday activities (e.g., cooking, grocery shopping) they engaged in with their families (Orosco and Abdulrahim 2017). The educator in this study used culturally relevant examples to build on students' prior experiences and this contributed to fostering the development of their mathematics identities as successful problem-solvers. Similarly, a teacher of African American students in one study incorporated stories into instruction featuring Black characters who solved everyday mathematical problems (Corp 2017). The students, who identified ethnically with the characters, found cultural inspiration to improve their problem-solving skills by seeking assistance, trying multiple strategies, or checking for accuracy.

In many studies, culturally responsive teachers incorporated interaction styles into instruction that shaped students' cultural identities which in turn promoted their mathematics learning. Specifically, the teachers in six studies used their students' native language during mathematics instruction to facilitate their learning and reinforce the value of their bilingualism (Bonner 2014; Cahnmann and Remillard 2002; Driver and Powell 2017; Gutstein et al. 1997; Quintos and Civil 2008; Matthews and López 2018). Similarly, three high school mathematics teachers encouraged their Latino/a students to process higher-level mathematics (e.g., reasoning, problem-solving) using their native language of Spanish (Gutiérrez 2002). During learning activities, the students, who were primarily English dominant, used both Spanish and English to discuss mathematics with their peers and code-switched between Spanish and English. In addition to promoting their students' bilingualism as a valuable mathematics resource, this served to foster mathematics comprehension and ownership in learning. The use of native language in mathematics learning is beneficial as it supports the development of positive cultural identities in the context of mathematics education. Also, it serves to rehumanize or transform perspectives about teaching and learning from deficit-based ideologies (e.g., English language hegemony) to asset-based approaches (e.g., code-switching, translanguaging) that honor students' linguistic heritage (Morales and DiNapoli 2018). In other studies involving culturally responsive interaction techniques, teachers of African American students integrated music, movement, clapping, rhythm, dance, oral story-telling, and choral responses to develop students' self-esteem in learning challenging mathematics concepts (Bonner 2014; Bonner and Adams 2012; Cholewa et al.

2012; Jackson 2013; Timmons-Brown and Warner 2016). As these studies have demonstrated, teachers can help all students realize their full potential by considering each child holistically when planning and delivering mathematics lessons (Hughes 2005).

Instructional Engagement

Instructional engagement is associated with students' reactions to and their interactions within learning environments, such as mathematics classrooms and is linked to several positive student outcomes, such as academic achievement and school persistence (Boekaerts 2016). Culturally responsive mathematics teachers can foster student engagement and ownership in learning by creating a learning context that responds to students' social, emotional, and cognitive needs (Hammond 2015). In several studies, teachers promoted student instructional engagement when connecting mathematical knowledge to their learners' cultural and linguistic backgrounds in various ways. These included integrating interdisciplinary content (Quintos and Civil 2008), making links to human experiences, such as relationships (Bonner 2014; Clark et al. 2013; Hubert 2014), drawing on cultural activities (Cahnmann and Remillard 2002; Jackson 2013; Lipka et al. 2005; Rubel and Chu 2012), incorporating stories with relatable characters (Corp 2017), scaffolding the formulation of meaningful research questions (Enyedy et al. 2011), addressing community based concerns (Tate 1995), and situating mathematics in the context of social justice issues (Gutstein 2003).

In five studies, teachers integrated opportunities for students to actively engage in group discussions to communicate their comprehension of mathematics concepts and consolidate their learning (Enyedy et al. 2011, Jackson 2013; Quintos and Civil 2008; Lipka et al. 2005; Rubel and Chu 2012). In two other studies, teachers related mathematics learning to issues that their students experienced at home which enhanced their students' motivation to make a difference in their own lives or the lives of others (Hubert 2014; Tate 1995). For example, students expressed a desire to put more effort in studying mathematics or had a vested interest in resolving problems that impacted their loved ones. Finally, several studies describing instructional engagement reported a variety of student reactions to their teachers' emphasis on cultural connectedness. These reactions included an increased interest and enjoyment in mathematics (Bonner 2014; Corp 2017; Driver and Powell 2017; Hubert 2014; Shumate et al. 2012), a persistence in problem-solving (Cahnmann and Remillard 2002; Corp 2017), and enhanced confidence in mathematics (Bonner 2014; Driver and Powell 2017; Gutstein 2003; Hubert 2014; Lipka et al. 2005). The students in Gutstein's (2003) study also expressed that they had developed a more positive attitude toward mathematics which included an acknowledgment that it is a useful tool to understand the world.

High Expectations

Teachers who set high expectations for student learning have a positive impact on their learners' academic achievement (Rubie-Davies et al. 2014). Maintaining high expectations for student learning and behavior is important to CRMT because students are more likely to achieve mathematics success when their teachers believe in

their abilities (Ladson-Billings 1997). The researchers in many studies reported that teachers set high expectations for student learning and behavior as they validated their students' sociocultural backgrounds when providing challenging mathematics experiences. In addition to communicating these expectations to learners, CRMT teachers provided support to students in meeting them which they demonstrated in different ways. For example, they committed themselves to providing tutorial support (Gutiérrez 1999, 2000), shared power with students in the classroom (Bonner 2014; Lipka et al. 2005; Matthews and López 2018), showed them care (Bonner 2014; Bonner and Adams 2012; Cholewa et al. 2012; Gutiérrez 1999; Hubert 2014), and complimented their strengths (Boaler and Staples 2008; Cholewa et al. 2012).

The teacher in Tate's (1995) study maintained high expectations for her students by designing a three-step implementation plan to scaffold their participation in resolving a community-based issue requiring a confluence of skill sets. First, students were asked to formulate a problem-solving strategy, then engage in investigative research and develop a set of strategies to address the problem, and finally implement their strategies. In another study, a third-grade teacher's high expectations for her learners extended beyond mathematics learning or discipline, such as exercising self-control and delaying gratification (Cahnmann and Remillard 2002). The teacher emphasized the importance of instilling these competencies in her students during mathematics instruction as she believed it would prepare them to become successful problem-solvers in the midst of challenging home environments. Teachers of successful high school mathematics students from CLD backgrounds communicated their high expectations in three main ways that embraced student diversity in mathematics learning (Boaler and Staples 2008). Namely, the teachers asked students challenging questions to support their continued mathematics thinking, nurtured persistence in their learners by emphasizing the importance of effort, and provided guidance in their mathematics reasoning by highlighting their use of effective learning practices. In Jackson's (2013) study, several elementary teachers integrated opportunities for African American students to lead mathematics discussions which challenged them to exercise their leadership skills and build their confidence in constructing mathematical meaning.

Student Critical Thinking

Critical thinking skills are higher-order thinking processes (e.g., analysis, evaluation, inference) that are important to everyday decision-making and problem-solving (Dwyer et al. 2014). CRMT practices that promote student critical thinking skills are important because they prepare students to become resourceful problem-solvers. In eight studies, teachers expected students to use multiple paths or strategies to solve problems and justify their solutions (Boaler 2008; Boaler and Staples 2008; Cahnmann and Remillard 2002; Gutstein 2003; Gutstein et al. 1997; Jackson 2013; Lipka et al. 2005; Quintos and Civil 2008). In two other studies (Raygoza 2016; Tate 1995), teachers fostered opportunities for students to use their critical thinking skills to address issues that affected their realities and those of others within their communities. The teachers in these studies prepared students to pose problems to solve,

collect and analyze data to formulate persuasive arguments, and propose multiple solutions based on their findings. In three other studies, teachers prepared students to apply their mathematics reasoning and analytical skills to interpret and evaluate data situated in real-world contexts which served to enhance their understanding of societal issues (Bartell 2013; Enyedy et al. 2011; Gregson 2013).

Educator Reflection

Teachers who practice culturally responsive teaching, critically examine their beliefs, values, and perceptions about race, ethnicity, and culture and how these concepts intertwine to shape their students' learning experiences (Howard 2003). Critical reflection is crucial for teachers because it can demonstrate their commitment to students' emotional well-being and academic success (Gay 2018). In three studies, teachers reflected on how their personal experiences as members of marginalized groups had shaped their cultural identities and values which in turn influenced their beliefs about teaching mathematics (Bonner and Adams 2012; Cahnmann and Remillard 2002; Gutstein et al. 1997). This reflective practice allowed the teachers to readily apply their knowledge about their learners' backgrounds and experiences in instruction thus recognizing them as valued mathematics resources. In another study, three mathematics teachers applied a critical lens to their teaching practice to ensure that instruction purposefully built on their learners' cultural strengths and lived experiences (Bonner 2014). The teachers created classroom environments conducive to learning mathematics content via instructional applications and communication styles that were pertinent to their students' lives. In two other studies, teachers engaged in a professional development project which prompted them to critique their own thoughts and behaviors about teaching students from CLD backgrounds (Aguirre and Zavala 2013; Timmons-Brown and Warners 2016). The training fostered a commitment in the teacher participants to improve their mathematics lessons in culturally relevant ways. In another study, high school mathematics teachers participated in a graduate level course on the role of culture in mathematics learning that prompted them to engage in critical reflection (Parker et al. 2017). The findings from this study revealed that the teacher participants changed their perceptions about mathematics teaching most notably by expressing the importance of knowing students on a "personal" level, not essentializing learners, and recognizing the contextual basis of mathematics problems.

Social Justice

Teaching for social justice involves recognizing that racial disparities (e.g., educational opportunities, resources, achievement) exist in society and committing oneself to act upon and challenge these injustices (Cochran-Smith et al. 2010). Social justice is important for CRMT because it helps students critique social inequities and the structural forces that perpetuate them (Ladson-Billings 1995a, b). In several studies, teachers raised student awareness of social injustice (Gutstein 2003; Gutstein et al. 1997; Quintos and Civil 2008) and empowered them to become activists to counter

inequalities in society (Bartell 2013; Gonzalez 2009; Gregson 2013; Raygoza 2016; Tate 1995) by using mathematics as a tool to analyze issues, such as power relations, societal oppression, and global poverty. As an example, a high school teacher implemented an issue-driven learning opportunity for her students that was grounded in mathematics (Gregson 2013). The students applied their mathematical knowledge (e.g., fractions, decimals, percentages), experience with farm work, and knowledge of immigration and labor issues to critically analyze the plight among farmworkers for better wages. The students were empowered to participate in activities to promote the cause for justice with support from their experienced teacher activist.

Collaboration

Researchers in many studies described collectivist approaches to learning and collaboration between students, teachers, family members, and the community as a way to enhance mathematical understanding (e.g., Bonner and Adams 2012; Gutiérrez 1999; Quintos and Civil 2008; Lipka et al. 2005). Collectivist approaches are important in some cultures (i.e., African American, Latino/a) because they reinforce values of interdependence and shared problem-solving learned at home and in the community over independence and competition (Veléz-Ibáñez and Greenberg 2005). Through collaborative efforts (e.g., curricula development, instructional planning) teachers can strategically incorporate “funds of knowledge” into instruction by drawing on the cultural and cognitive resources that students and household members bring to the classroom (Moll et al. 2005). Collaboration is important to CRMT because it empowers students, teachers and their partners in mathematics education to become agents of successful learning. As an example of this collaboration, African American parents in three studies were proactive participants in their children’s mathematics learning (Berry 2005, 2008; Martin 2006a). These African American parents contributed to their children’s mathematics success by ensuring their access to educational opportunities outside of school (e.g., special mathematics programs) and providing homework assistance to advance their children’s mathematical learning. In summary, the parents demonstrated a commitment to supporting their children’s mathematics development and were role models to them as knowers and doers of mathematics.

In many studies, teachers integrated collaborative learning experiences (e.g., pair work, group work) into instruction. In five studies (Boaler 2008; Boaler and Staples 2008; Cholewa et al. 2012; Gutiérrez 2002; Jackson 2013), teachers created collaborative learning opportunities for students in which they were encouraged to enact responsibility for each other’s learning. Students were taught to ensure that group members were on-task and understood the material. In another study, a teacher facilitated deliberations among groups of sixth-grade students by using narrative structure, discourse, and questions to help students formulate a research question for their statistics project (Enyedy et al. 2011). The ongoing negotiation helped the students reach a consensus on a topic that was both relevant and meaningful to their lives and aligned with project expectations. This process helped students to co-construct knowledge about the measures of central tendency (i.e., mean, median, mode)

within a culturally relevant educational environment. In two other studies, teachers in special education settings provided frequent opportunities for their Latino/a students to practice challenging math language and solve problems in pairs or small groups which facilitated their mathematics learning (Orosco and Abdulrahim 2017; Shumate et al. 2012). In another study, a teacher integrated collaborative group work into her mathematics lessons on quadratic and exponential functions which contributed to enhancing their mathematics comprehension and participation in class (Hubert 2014). The students acknowledged how group work encouraged their active participation in learning mathematics content that incorporated topics from their everyday lives.

Furthermore, teachers in two studies maintained collaborative working relationships with their colleagues to promote mathematics success in educational environments that integrated students' sociocultural experiences (Gutiérrez 1999, 2000). These teachers, at two high schools serving a predominantly CLD population, worked closely with their mathematics departments to ensure that their students were prepared to take advanced mathematics courses by their senior year. To achieve this, the teachers and their mathematics department chairs ensured that resources met their students' learning needs, provided tutoring support to students, and ensured that instruction built on students' strengths and interests. These efforts demonstrate how teachers and administrators can collaborate to capitalize on students' everyday knowledge and experiences to help them achieve success in mathematics.

Finally, in several studies, teachers purposely built relationships with families and the community and incorporated this knowledge into instruction. As an example, two-fifth grade teachers in two studies invited family members to learn mathematics in their classrooms (Bonner and Adams 2012; Quintos and Civil 2008). This approach helped the teachers gain a better understanding of their students' home lives and household funds of knowledge that informed their teaching. In two other studies, American Indian/Alaska Native students (Kisker et al. 2012; Lipka et al. 2005) participated in a mathematics curriculum created in collaboration with university researchers, indigenous cultural experts, and community elders. These culturally relevant curricula facilitated students' learning of key mathematical concepts and their application in problem-solving activities.

Discussion

The purpose of this research synthesis was to describe the current implementation of culturally responsive mathematics teaching (CRMT) with culturally and linguistically diverse (CLD) students. Thirty-five studies conducted between 1993 and 2018 within a K-12 U.S. public school context were included in the review. Findings resulted in seven themes that highlighted promising CRMT practices: cultural identity, instructional engagement, educator reflection, high expectations, student critical thinking, social justice, and collaboration. These themes contribute to validating the use of asset-based pedagogies in mathematics education to engage and empower students from historically marginalized backgrounds (Leonard 2008).

Unfortunately, many students from CLD communities do not encounter schooling experiences that are culturally responsive (Gay 2018; Khalifa et al. 2016). The majority of classrooms do not connect instruction and curricula with CLD students' experiences and realities. To support a more equitable educational environment, mathematics education needs to validate CLD students' cultural and linguistic strengths to enhance student learning (Bartell 2013; Celedón-Pattichis et al. 2018). Through this sociocultural interface, students have the opportunity to engage in mathematics learning that is cognitively situated (Ladson-Billings 1997). That is, providing students with a cultural frame of reference during mathematics instruction allows them to bridge academic content with their home and community experiences to enhance their mathematical development.

The CRMT literature reveals that teachers who apply culturally and linguistically affirming practices can cultivate learning environments where learners are empowered to achieve mathematics excellence (Gutiérrez 2013). Mathematics classrooms can build positive student identities with culturally responsive curricula (e.g., storybooks, real-world projects) and interaction styles (e.g., story-telling, native language) while maintaining high expectations (e.g., sharing power, being caring). These practices promote learner engagement and mathematics comprehension which can help students become confident problem solvers. Moreover, instruction that is responsive to students cultural and linguistic needs contributes positively to student mathematics performance (e.g., Driver and Powell 2017; Kisker et al. 2012; Matthews and López 2018; Shumate et al. 2012).

In addition to possessing the knowledge and skills for implementing culturally responsive practices, CRMT research has shown that creating equitable and inclusive learning environments requires teachers to have cultural dispositions that embrace diversity (Vázquez-Montilla et al. 2014; Williams et al. 2016). Teachers who are culturally competent engage in critical reflection about race and culture which informs their mathematics teaching and supports the sustainable development of practices that are culturally responsive (Williams et al. 2016). Moreover, they endeavor to maximize student learning potential by using families and community members as knowledgeable mathematics resources. In essence, culturally responsive mathematics teachers actively seek out opportunities to capitalize on students' cultural and linguistic resources in the classroom (Nasir et al. 2008).

Finally, mathematics teachers who are culturally and linguistically responsive to their learners provide mathematics instruction that challenges them to think critically (Williams et al. 2016). In this vein, teachers prepare students to use mathematics as an analytical tool and apply higher-level mathematics skills to address local, national, or global issues. They empower students to become agents of social change by allowing them to take ownership in creating and implementing action plans that align with learning expectations. As students begin to see mathematics as valuable and worthwhile, they may begin to view themselves as knowers and doers of mathematics (i.e., productive disposition) which can have a positive influence on their learning (Philipp and Siegfried 2015).

In summary, the findings of this synthesis show that mathematics teachers who bridge the divide between home and school with CRMT practices can provide an instructional context for students that is supportive, engaging, and challenging. This,

in turn, can promote the development of positive student cultural identities which is related to how students perceive their mathematics ability. Finally, teachers who realize how culture and mathematics are inextricably linked and apply this understanding in their classrooms are creating accessible opportunities for students from CLD backgrounds to learn mathematics (Nasir et al. 2008).

Implications for Policy, Practice, and Research

In view of the growing research base on culturally responsive mathematics teaching (CRMT), policymakers, teacher educators, professional development facilitators, and researchers should aim to develop culturally competent teachers who can meet the mathematics learning needs of an increasingly diverse student population. This synthesis found that teachers who apply CRMT methods provide a powerful nexus between their students' sociocultural experiences (found critical to learning and development) and classroom instruction, thus, contributing to their students' mathematics cognition. Evidence from this synthesis indicates that research, practice, and policy may need to provide more for teachers than the typical evidence-based practices being implemented in the majority of U.S. public schools.

Policy

Federal, state, and local policymakers must realize that many students from marginalized communities have not been benefiting from traditional mathematics instruction (Celedón-Pattichis et al. 2018). In view of this, policymakers must develop policy that provides school personnel (i.e., educators, administrators) with the culturally responsive tools to implement across learning environments (Khalifa et al. 2016), such as mathematics classrooms. As an example, this synthesis found that when teachers were prepared with CRMT methods, they had the capacity to improve CLD students' engagement, learning, and self-efficacy in mathematics. Thus, school policy may be needed to ensure that mathematics teachers are provided with culturally responsive preservice training and professional development.

Practice

In addition, research indicates that many teachers are underprepared to address the learning needs of students from CLD backgrounds (Vázquez-Montilla et al. 2014). The majority of mathematics teachers today continue to provide instruction that discounts students' cultural and linguistic strengths (Celedón-Pattichis et al. 2018). Accordingly, culturally competent teachers would need to develop a sociocultural context for teaching and learning mathematics that can maximize student learning potential. To guide their mathematics teaching, teachers should also be directed to culturally responsive theory (Turner et al. 2012). Exposing teachers to culturally responsive theory would promote an understanding of how sociocultural experiences provides context to learning and the importance of this application in mathematics education (Vygotsky 1978). In addition, this culturally responsive training

may help teachers recognize that their students' family and community members are co-constructors of mathematical knowledge whose unique strengths and experiences should be capitalized on in the classroom. When teachers understand the sociocultural context of mathematics education, they may be more likely to realize the benefits of CRMT and design learning environments that align with this instructional approach.

Research

Finally, the results of this synthesis suggest that more descriptive research is needed on CRMT practices with CLD students, including documentation of its connection to student outcomes (Sleeter 2012). Qualitative research represents the movement from a traditional positivist orientation of knowledge construction (e.g., quantitative) to post-modern interpretive forms (Denzin and Lincoln 2018). In qualitative research, meaning is constructed by individuals based on their interactions with their world at a specific point in time and within a particular context (Merriam and Grenier 2019). Although descriptive research continues to be marginalized as a source of evidence in determining social policy (Erickson 2018), it can provide an in-depth understanding of practices that might be effective for students (Orosco and Abdulrahim 2017). Thus, qualitative research can provide much-needed insight into how teachers can effectively apply CRMT practices within our schools to promote student success.

Limitations

This research synthesis has several limitations that need to be acknowledged. First, relevant studies may have been missed from the review as a hand search of journal articles was not conducted. Second, although this synthesis includes several quantitative and mixed methods studies, it does not report quantitative findings which may have provided further insight into the effects of CRMT on various indicators of student achievement (e.g., test scores, perceived self-efficacy, instructional engagement). Third, this review excluded unpublished studies, which may have contained rich description on the topic (Major and Savin-Baden 2010).

Conclusion

In conclusion, as learners bring a wealth of cultural and linguistic experiences into the classroom, it is pivotal for teachers to apply CRMT practices. Research has shown that CRMT can promote student engagement and enhance learning among students from CLD backgrounds across grade levels. In view of this, teacher preparation and professional development programs should focus on fostering teacher disposition for CRMT in addition to building knowledge and competence in using this instructional approach. Teachers who apply CRMT practices in their classrooms have the potential to provide effective mathematics education for CLD students.

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