

# CULTURALLY RESPONSIVE PEDAGOGY IN MATHEMATICS

**Kenta Nagasawa**

*Vanderbilt University, Peabody College*

## **Abstract**

*Purpose:* This paper is a thematic literature review to examine the current state of research about Culturally Responsive Pedagogy in mathematics. The main themes are students' perception, teacher education for pre-service teachers, and professional development for teachers.

*Research methods/approach:* Literature was collected from Eric, which is a research engine of the education field. Also, Google Scholar is used to find articles of major scholars introduced by Dr. Rich Milner, who is the instructor of this course.

*Findings:* Students faced microaggressions in mathematics class, which discouraged them to learn mathematics. The effect of teacher education was inconsistent in terms of the awareness of culturally responsive pedagogy and lesson plans. Research of professional development pointed out the pedagogy of mathematics class did not match with the culture of African American students.

*Implications for research and practice:* It would be interesting to conduct long-term or follow-up research to find the teacher's practice after taking a professional development program. Also, it is critical to expand the research scope beyond African American and Latino students. Finally, evidence-based research is needed to change the political context.

*Keywords:* culturally responsive teaching, mathematics, teacher education, professional development, students' perception

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In the U.S., culturally responsive pedagogy (CRP) is increasingly important to be practiced in order to achieve equity in education. Although it depends on schools and geographic area, there is a case that white students are not majority although the majority of teachers is white (Milner, 2010). Based on this, it is critical to consider equity for children with different backgrounds such as race and culture. Moreover, it is interesting to deal with CRP in mathematics in this paper because I believed mathematics was neutral when I taught it at a middle school in Tanzania for two years from 2015 to 2017. The contents of mathematics at Grade 9 in Tanzania were quite similar to that of Japan, although the number of contents was more than that of Japan. Therefore, I thought that mathematics was common knowledge in the world through this experience. However, I came to consider that it may actually be a cultural phenomenon during a discussion in my Culturally Responsive Pedagogy class where I learned that the current education system came from the Western world.

This paper examines phenomena within mathematics education in terms of CRP and what is the “current state” of mathematics in CRP. Also, it will reveal a historical background to understand the current situation of this research interest. This literature review is a thematic literature review. For finding major themes, Milner (2017) presents explicit themes of research of CRP in mathematics. I classified themes into three categories based on this article: 1) students’ perception, 2) teacher education (conceptualized as teacher training for pre-service teachers), and 3) professional development for teachers. In this paper, these themes are used to represent the current situation of the research and provide implications for the future of CRP in mathematics.

A conceptual framework of representing the attribute of CRP is raised in this part. First, the term “culture” can be vague, so it is important to define this term. Gay (2018) described culture as “a dynamic system of social values, cognitive codes, behavioral standards, worldviews, and beliefs used to give order and meaning to our own lives as well as the lives of others” (p. 8). The point is that culture is not static but rather dynamic, which implies that it may change depending on a person, time, environment and other factors.

Second, Ladson-Billings (2009) showed three critical tenets of CRP: students’ learning, cultural competence, and sociopolitical consciousness. It should be careful that students' learning does not mean merely a test score. This tenet included that students were encouraged to demonstrate what they knew in learning activities. The second tenet is cultural competence which aims to develop students’ perception about their history, literature, art, music, dance, and values. The last tenet meant that teachers who practiced CRP expected students to make a connection between their in-school lives and their out-of-school experiences.

Gay (2008) provided eight qualitative attributes of CRP: validating, comprehensive and inclusive, multidimensional, empowering, transformative, emancipatory, humanistic, and normative and ethical. “Validating” is used for reflecting on the cultural knowledge and prior experiences to make a connection to what students learn and their life. “Comprehensive and inclusive” is used to develop intellectual, social, emotional, and political development with cultural resources. “Multidimensional” means to include curriculum content, learning context, classroom climate/management, the relationship between student and teacher, instructional techniques, and assessments. “Empowering” represents that students are believed to be better human beings and more successful learners. “Transformative” contributes to students’ ability to develop the knowledge, skills, and values needed to become social critics - all of which are skills needed to take action. “Emancipatory” is liberating, which enables students to focus more closely and concentrate more thoroughly on academic learning. This tenet also contributes to

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making students realize that only one “truth” does not exist permanently. “Humanistic” addresses human welfare, dignity, and respect of various individuals and groups. “Normative and ethical” is helpful to enlighten students how and why education policy and practices has been practiced based on Eurocentric culture dominating ethnic groups.

Milner (2010) also showed five elements of CRP which should be considered: color blindness, cultural conflicts, myth of meritocracy, and low expectations and context-neutral mind-sets. Color blindness means that educators avoid racial conception in education, recognize race as irrelevant and worthless to the success of students, and White educators do not recognize their privileges associated with their race. Cultural conflicts consider inconsistency in teaching and learning contexts between teachers and students based on factors such as race, gender, age, geography, and socioeconomic status. It may be shaped historically and contemporarily. Also, educators consider their culture is superior to that of students. The myth of meritocracy means that educators believe their success is attributed to their ability, performance, effort, and talents – this indicates that structural power and barriers are not considered within the idea of individualism. Deficit mind-sets and low expectations are when educators focus on what students do not have instead of looking at what they bring to the classroom. In addition, they have a narrow point of view about what is defined as “normal” and “successful” based on their cultural references. Moreover, they do not believe students with cultural diversity are able to succeed academically, which causes low expectations for their students. A context-neutral mind-set means that educators do not consider how contextual, ecological, and environmental conditions shape opportunities to learn. Also, they concentrate on subject matters, and they do not care about understanding the complexities inherent in different settings such as urban, suburban, or rural areas when teaching in school.

This literature review is thematic and consists of a research methods section, findings section, and discussion and conclusion section. In the research method section, I present how I collected articles and explain how I selected them. I explain how I categorized themes of research of CRP in mathematics in the findings section. Finally, I will discuss what is found through the articles, while mentioning methodology and implications.

### **Research Methods**

First, the databases were searched for peer-reviewed journal articles since 2000 using the following keywords: culturally responsive pedagogy and mathematics, and culturally responsive teaching and mathematics. The specific time span of articles selected was from 2000 to 2018 in order to capture the current situations about the research topic and to gain insight into implications and future research. As for the research method to find articles, I used Eric, which provides rich educational articles reflecting on culturally responsive pedagogy.

Second, I used articles of prestigious scholars who specialize in culturally responsive pedagogy and mathematics. Since Eric did not find their articles, I used Google Scholar by entering their names and ‘culturally responsive pedagogy and mathematics’ into the search bar. I found twenty-four articles in searching “culturally responsive pedagogy AND mathematics,” fifty-four articles for the words “culturally responsive teaching AND mathematics” in Eric, and found twelve articles in Google Scholar. I selected articles that were most relevant to culturally responsive pedagogy and mathematics. When categorizing themes, I used an article of Milner

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(2017) which presented three themes about culturally responsive pedagogy and mathematics: 1) students' perception, 2) professional development, and 3) teacher education for pre-service teachers. Although I write a thematic literature review in this paper, it is critical to see the historical context to understand the current situation. I referred to historical context of culturally responsive pedagogy in mathematics field in this paper to some extent.

Besides these articles I found through search engines, I also used books that provided conceptualizations of culturally responsive pedagogy. As mentioned above, Ladson-Billings (2009) proposed three tenets of culturally responsive pedagogy: 1) academic success, 2) cultural competence, and 3) critical consciousness. Also, Gay (2018) defines culture and provides eight tenets of culturally responsive pedagogy. He defines culture as "a dynamic system of social values, cognitive codes, behavioral standards, worldviews, and beliefs used to give order and meaning to our own lives as well as the lives of others" (Gay, 2018, p. 8). The eight tenets are validating, comprehensive and inclusive, multidimensional, empowering, transformative, emancipatory, humanistic, and normative and ethical explained in the introduction part above.

Finally, Milner (2010) presented five elements of CRP which should be considered: color blindness, cultural conflicts, myth of meritocracy, low expectations and context-neutral mind-sets. When I classify research topics about mathematics and CRP, I show three themes proposed by Milner (2017): 1) students' perceptions of practices, 2) the need for teacher education for those who are pre-service teachers, and 3) professional development. This paper follows these categories and aims to reveal the current features of mathematics and CRP.

### Findings

#### *Historical perspective on CRP in Mathematics*

In order to explain current conditions of CRP in mathematics, it is important to understand the historical context behind it. Tate (1995) contributed to examining the history of mathematics in CRP by addressing previous research focusing on mathematics pedagogy for African American students. It was found that traditional mathematics instruction was "foreign pedagogy," which led to the lack of motivation to learn mathematics and poor academic performance for African American students. Education was built on the thinking, experiences, and desires of Whites, which were not appropriate for African Americans. Therefore, he posited that it was important to have an "Africentric approach" to achieve equity by incorporating African American tradition and experience into mathematics education. "Africentric approach" is to focus on African American students within the context of their experience and culture, which enables them to link learning contents with their experience. However, Tate (1995) pointed out the difficulty for students to learn mathematics with their culture. For instance, students who tried to center their culture risked being put down by teachers who focused on traditional mathematics content. In order to address this threat to be put down, he argued that mathematics teachers must understand African American culture and be willing to incorporate it into the classroom. Then, mathematics teachers should practice CRP in their classes by giving students not simply defined questions but problem-solving questions that trigger students' interests and collaborative learning in order to answer them.

There are also two major theoretical backgrounds of mathematics education in CRP. According to the same article (Tate, 1995), it is important to raise up the concepts of cultural

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practice theory and critical theory. Cultural practice theory was defined as follows: “Culture practice theory is based on the idea that knowledge is situated within particular contexts” (p. 169). This theory contributes to addressing the discontinuity between schooling and outside school life. However, there was a missing point that the cultural practice theory did not cover in analysis of the relationship between cultural discontinuity and social inequality. In order to supplement this void, critical theory was used to address the relationship between political and economic inequality and mathematics education, which led students to participate in society as its members.

Finally, Tate suggested that it is critical that teacher changes their traditional pedagogy, and they should practice CPR in their class. One of the features of the instruction reflecting on CRP is problem-solving. Traditional mathematics instruction employs solving routine, well-defined problems, which was less attractive to students. On the other hand, the instructions in mathematics with CRP gives students open-ended questions by formulating questions and representing real situations verbally, numerically, or graphically.

Finally, Martin (2012) discussed how the research on Black children and mathematics developed. A dominant research topic at the time was a set of cultural and cognitive research for negative outcomes. Then, the research field was expanded, which led to researchers beginning to address the relationships among cognitive/non-cognitive, structural, institutional, and ideological factors. There were four primary research fields to address these factors: 1) the racialized characteristics about children’s mathematics experience inside/outside school, 2) students’ belief about their ability to participate in learning mathematics based on socializing experiences, 3) their motivation to learn mathematics, and 4) the co-construction of mathematics identities and other social identities.

### **Thematic Perspective on CRP in Mathematics**

This section consists of three parts presented by Milner (2017): 1) students’ perception, 2) teacher education, and 3) professional development. Students’ perception addresses their input, satisfaction, and motivation toward mathematics class practiced by their teachers. The research on teacher education, of which this paper mainly addresses pre-service, aims to establish a robust cognitive way of pre-service teachers which leads to practicing CRP in their class when they start their career. Professional development for teachers focuses on building an instructional practice to cultivate students’ interest in mathematics.

#### *Students’ Perception*

It is essential to understand students’ perceptions in their mathematics class because it enables us to understand what challenges students confront within their mathematics class. This perception can be invisible from the teachers’ perspective. Moreover, it is interesting to reveal whether traditional mathematics class based on teacher-centered pedagogy has been changed into the class reflecting on CRP or not.

Nasir & Hand (2008) focused on the two contrasting settings which were mathematics class and basketball club activity to reveal the different perceptions of students using an analogy comparing mathematics and basketball. In this research, she focused on three areas: 1) access to the domain, 2) opportunities to take on their roles, and 3) opportunities for self-expression in the

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practice. Participants were eight African American students who were also basketball players at their high school in Northern California, four of whom were high math achievers and four of whom were average math achievers. They were selected as subjects in this research based on recommendations from teachers and coaches. This research used videotape and interview methods to observe students, teachers, and coaches. It was found that students played a multidimensional role in the practice of basketball, had opportunities to express themselves, and contributed to their teams as a result. On the other hand, they did not have access to the domain, which meant that they had little roles and opportunities to express themselves in mathematics class. In other words, their learning opportunities were limited in mathematics class due to low engagement. In this result, it is critical to consider to promote students' engagement in mathematics class assigning their roles, not focusing on not only skills and knowledge.

McGee & Martin (2011) showed racism within the mathematic performance of Black students in college although African American students manage effectively against racism in schools. In this study, 23 participants who were high-achieving Black mathematics and engineering students were interviewed over the course of the 2006-2008 academic years. They were 14 males and 9 females whose age was from 19 to 45, with the median age being 26.3 years. The findings showed that the African American students were considered inferior to other students, particularly White and Asian students, in mathematics and engineering. It was also pointed out that there was a lot of research about professional development for teachers in K-12 schools, but there were few programs for professional development for college scholars.

Nasir & Vakil (2017) researched a case study referring to a STEM program for students in an urban area. There were two stages of the research approach. The first phase was an ethnographic study across elementary, middle, and high schools in a large urban district in Northern California. Data in this phase included seven teachers, 12 students, two parents, and five school administrator interviews and field note observations. The second phase was a design study to create opportunities for students to address school-level equity issues in a computer science course at Bay Prep. In this case, the study revealed that this academic program failed to connect its contents to students' experience and interest, which meant that students did not understand why they studied these contents. Black and Latino students felt unsupported and isolated during the STEM classes. One student stated, "I just didn't feel comfortable in it cause it was strictly White so I was like I don't think I can deal with this" (p. 392). Moreover, this research mentioned the absence of CRP, meaning that the pedagogy and curriculum without the attributes of CRP are not based on the contexts of Black and Latino students. In other words, the teaching and learning activities largely excluded social justice or CRP approaches in the classroom. In the Mathematical Sciences Academy, students reported that they viewed the learning space in STEM classes as a "White" space and saw Whiteness prevailing through subtle exchanges and in the classrooms.

Riskowski & Olbricht (2010) examined students' views of diversity through a multicultural mathematics activity in a middle school. The sample population was 81 students drawn from five 6th to 8th-grade mathematics classes in a rural middle school in Indiana. This project expected students to participate in a nontraditional, open-ended manner by expressing their ideas and beliefs. For statistical analysis, students responded to a 7-question pre-post-evaluation designed to elicit their conceptual understanding and personal thoughts on diversity. In addition, interviews and group discussions were conducted during a conversation led by the authors to investigate the reflexive questions at a deeper level. They found that this kind of activity in the mathematics classroom had the positive effect of enhancing confidence and

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improving diversity awareness, which in turn could encourage students to be aware and proactive of pursuing equity for everyone, regardless of background. In detail, this mathematics class was based on project-based learning, which was designed to encourage student reflection, their responses in the discussion, and reflexive writing. The study concluded that the class with the highest engagement of students was able to develop meta-cognition, diversity awareness, and collaboration skills for working with others from a different background.

Rodriguez, Bustamante, Pang & Park (2004) aimed to reveal the effect of a university outreach program on academic achievement and identity development among culturally diverse tenth-grade students. Most students would be the first person from their family to attend a four-year college or university and the majority were from low-income backgrounds. They were elected through written applications and interviews from a counselor. Quantitative data was collected from participants consisting of 193 students by conducting The Test of Integrative Process Skill (TIPS) to measure mathematical and scientific thinking. In addition to the test, group interviews had been conducted to find effectiveness in promoting students' academic and cultural identity and to provide supplemental data for the test outcomes. In this program, the curriculum was developed for cultivating scientific reasoning and thinking skills through student-centered instruction. The staff who engaged in developing the curriculum were aware that culture plays a critical role in adolescents' development and learning. This program was conducted during the summer and there was only six weeks of intervention, but the results showed that there was a positive influence on the academic score and students' identity development. A students' response demonstrates the power of this program: "What I liked about SEP is that I actually felt the power when I came here. Here you feel more comfortable and accepted because no one's really, like, making racist comments and making you feel uncomfortable because we're all on the same level. We all had equal respect for each other" (p. 50).

### *Teacher Education*

I found several articles that addressed teacher education for pre-service teachers, which contributed to developing an awareness of CRP and assessing the effect of teacher training focusing on CRP (Aguirre, Zavala & Katanyoutanant; 2012, Appelbaum; 2009, Brown & Crippen, 2016; Hernandez, Morales & Shroyer, 2013). First, Brown (2016) found the effect of a teacher education program was inconsistent. The methodology in this research took the form of a multiple case study and a sample of 19 pre-service teachers who majored in mathematics and science consented to participation. The authors designed The Growing Awareness Inventory (GAIIn) to aid pre-service teachers in identifying and incorporating students' cultural and linguistic backgrounds into instruction. In addition to responding to GAIIn, the lesson plan was also examined in middle school and high school settings. Pre-service teachers recognized the importance of CRP, but their lesson plans did not always reflect aspects of CRP. The author identified two factors that caused this inconsistent effect: 1) the lack of additional structure to support pre-service teachers' development and 2) the lower connection between CRP and other teacher education courses.

Second, research on a mathematics methods course addressing CRP revealed a positive influence on pre-service teachers (Aguirre, Zavala & Katanyoutanant, 2012). The study sample consisted of 40 pre-service teachers taking a mathematics methods course at an urban university in the Pacific Northwest region. This research collected data asking pre-service teachers to evaluate their lessons by using the culturally responsive mathematics teaching (CRMT) tool. In

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this assessment, they rated the quality of their lessons across the dimensions by themselves for quantitative analysis. For the qualitative analysis, they used the rubric categories which were mathematics discourse, student engagement, and language to understand the general content of explanations and reflections by the subjects. Trainees were willing to support academic language for second language learners, as well as integrating cultural knowledge and social justice into mathematics lessons. Through the course, they felt confident that they could improve students' engagement which helped students to enhance mathematical thinking.

Moreover, it was found that a curriculum structure based on CRP could make a difference in children's learning (Appelbaum, 2009). This research described the way of teaching and learning structure that encouraged children to take responsibility for their own learning. College students who were in teacher training courses practiced mathematics instruction based on a mathematics curriculum that reflected the assets of CRP. Then, they met groups of 8 to 10 children in their schools twice per week for periods of one to two hours. They created space for children to learn mathematics and led them to connect mathematics and real life. Although even the college students who engaged in this instruction were skeptical about this practice, parents and school personnel were excited about the children's accomplishments, media interests, and enthusiasm.

Hernandez, Morales & Shroyer (2013) developed a model of CRP in mathematics and science education. They aimed to use it for the preparation and assessment of teacher candidates and their professional development, as well through theoretical research to address a unifying approach in teacher education to guide the preparation and assessment of CRP. This model contained five thematic categories: 1) content integration including other cultures, building positive relationships with students, and holding high expectations; 2) facilitating knowledge construction building on what students know, using real-life examples, and promoting critical thinking; 3) prejudice reduction using native language support, fostering positive interactions among students, and creating a safe environment; 4) social justice requiring teachers to act as an agent of change and assisting students to become good citizens; and 5) academic development expecting teachers to help all students develop their knowledge and reflecting the needs of diversity of background and learning styles. They researchers insisted that it was not enough for teachers to understand effective instruction but also understand increasingly diverse students in their classrooms.

### *Professional Development*

Professional development is critical to research because of diversity in schools in the U.S. White teachers account for the majority, but the student with color represents majority in some schools (Milner, 2010). Therefore, it is meaningful to examine current situations around professional development and what are key elements of professional development to practice CRP in school.

Cordell & Martin (2015) implied the importance of professional development for mathematics teachers. This research focused on Latin students who were in undergraduate programs, although 27 participants were Asian, White, and African American. They were expected to answer how their workshop participation evolved and how success-oriented shifts in their participation related to or did not relate to their mathematical and racial identity development. The research found that mathematics teachers could aid in the empowerment of students by caring about constructing their interconnected identity and supporting strengthened identity development through mathematics engagement. Also, they suggested that it was crucial

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to create comfortable and non-intimidating space for students to engage in classrooms, treating students and encouraging them to treat each other as “holders and creators of knowledge” (Cordell & Martin, 2015, p. 44).

According to Carter, Hawkins, and Natesan (2008), mathematics is cultural. In this research, a school district located in the southeastern part of Texas was studied because it had a population of African American students that was large enough to form a sample. The authors examined the relationship between *verve* and the academic performance of selected African American middle-school students in reading and mathematics in an urban setting. In this article, the definition of *verve* is “the propensity for energetic, intense, stylistic body language and expression” (Carter, Hawkins & Natesan, 2008, p. 30). They found that higher levels of *verve* which African American students had had a greater negative impact on mathematics performance than reading performance. They pointed out that this is because mathematics may be a very abstract and non-stimulating discipline for them, which led to the low engagement of African American students because these contents and pedagogy did not attract them. In order to address this issue, it was pointed out that students with high levels of *verve* such as African American students should be assigned to teachers who practice CRP because the teachers can practice interactive instruction. Also, it was recommended that professional development training for educators continue in CRP through hands-on learning experiences and specific training in mathematics.

Bonner & Adams (2012) conducted a case study for identifying key factors to succeed as mathematics teachers. They communicated with community members to find mathematics teachers who highly succeeded in teaching mathematics. They introduced an African American woman who taught a neighborhood elementary school for 30 years. There are four key elements raised for students’ success: 1) communication used to establish a relationship with students and develop students’ self-esteem; 2) knowledge, which meant using one’s personal history, students, and community to link to mathematics class; 3) trust/relationships, which must be built for empowering students, promoting their learning beyond test scores, and developing confidence in racial and cultural identity’ and 4) constant reflection/revision, including reflecting on teachers’ own practices and keeping students learning. These elements should be used not only by teachers but also by school administrators and policymakers as an evaluative or reflective observation tool. Also, the researchers recommended these elements be included for professional development and curricular reform.

Hudley & Mallinson (2017) designed a model of professional development for educators to establish cultural and linguistic competence and to disseminate information about how they view the relevance of language, communication, and culture to STEM teaching and learning. There were 60 K-12 STEM educators from schools in Maryland and Virginia that served African American students in this workshop. One of the large contributions of this research was that they conducted follow-up research after the workshop. They emailed participants a link to a post-workshop survey, conducted a focus group, and conducted 20 semi-structured interviews lasting one to two hours each. In the results of this research, participants who attended the workshops found language and culture to be relevant to their professional careers and their interests in language and culture increased. Also, they pointed out that supportive systems for STEM education in culture and language had yet to fully permeate K-12 educational settings. Moreover, this research revealed challenges STEM education faces in terms of CRP. Participants who participated in this workshop recognized that educators who engaged in STEM should be interested in non-STEM material. Second, they pointed out that they had limited access to

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training available. Third, they may still feel the lack of enough time or space to learn such additional material and incorporate it into their curriculum.

Bartell, Parker, and Novak (2017) researched the change in teachers' perceptions toward their normative beliefs and practice regarding student expectations and to what extent this change indicates the need to build capacity to engage in CRP. The program in this research was part of a graduate program for practicing secondary mathematics teachers at a public doctoral-granting university in the Rocky Mountain region. Almost all participants were White teachers and their teaching experience varied from 2 to 22 years. Hispanic students were the largest minority in their schools. The authors conducted narrative inquiry research to understand the teachers' perspective shift. The results showed that teachers came to have more willingness and confidence in reaching out to, understanding, and supporting students they initially found puzzling. Also, the authors pointed out the importance of empathy and for them to take action on social justice.

Powell, Cantrell, Malo-Juvera, and Correll (2016) examined the relationship between implementation of CRP and student achievement in reading and mathematics. They used a mixed-methods design to answer their research question. Data was collected from classroom observation, students' test scores, and teacher interviews. In this study, 27 teachers who were all White females from four elementary schools participated along with 456 students. The results showed that students of high implementers of CRP had significantly higher achievement scores in reading and mathematics than students of low implementers. The authors also mentioned challenges to implement CRP. These included establishing a trustful relationship with students and their families, promoting and developing collaboration, assessment/instructional practices, discourse practices, and sociopolitical consciousness.

Jett (2013) proposed Africana mathematics in higher education and argued the importance of developing CRP skills for scholars in college. Through the experience of the author and public data, it was indicated that CRP was needed for mathematics in higher education for African American college students. He faced the concept of "identity thief," which is situations when some professors at colleges give their lectures without culturally responsive pedagogy. Moreover, there were 15,993 mathematics majors produced nationally, but only 819 African American students completed a mathematics major in 2011-2012. Furthermore, it was stated that mathematics professors at colleges and universities rarely had opportunities to be exposed to CRP, unlike K-12 mathematics classroom teachers who have optional or mandated professional development opportunities.

Brenneman, Lange, and Nayfeld (2019) outlined the main elements of high-quality professional development for early childhood teachers to provide children with effective STEM education. There were ten best practices to be conducted for the professional development: 1) include educators and administrators; 2) include supporting coaches; 3) build teachers' content knowledge; 4) pay attention to teachers' attitudes and beliefs; 5) interact with teachers; 6) connect to classroom practice; 7) get educators to reflect on practice with feedback; 8) create a community of practice; 9) be sustainable for long term; and 10) be individualized. The effect of professional development with these elements is being tested to examine whether the model changes teacher attitudes, beliefs, and teaching practices, as well as whether or not student learning improves.

## Discussion & Conclusion

This literature review aims to examine the current conditions of CRP in mathematics through thematic perspectives including historical review. Historically, it was found that the research of mathematics in CRP started from the culture practice theory, which addressed the discontinuity between inside school and outside school. Then, critical theory was practiced in this research field to deal with the relationship between cultural discontinuity and social inequality. It was also revealed that African American students faced “foreign pedagogy” in mathematics class, which was a traditional instruction of teaching mathematics with low student engagement.

In terms of thematic points of view, there are three types of research themes: students’ perception, teacher education, and professional development. From the literature addressing students’ perception, even now CRP is not practiced in mathematics class. The mathematics class has focused on giving knowledge to students with low engagement, which discourages them to learn mathematics. Students in college were confronted with racism, which raised the need for professional development for instructors in college about CRP. To promote a safe learning environment, it is crucial for mathematics teachers to recognize the role of mathematics, which includes the empowerment of students to succeed by enabling them to appreciate their role as agents of change and use mathematics as a tool to influence societal justice (Lucey & Tanase, 2012). Regarding teacher education, its effect is inconsistent from the research of teacher perception about CRP and the observation of the lesson plan. However, teacher education contributes to increasing the willingness to incorporate CRP in class. For professional development, it was revealed that professional development shifted the teacher’s mind, which acknowledged the importance of empowerment, caring, and the connection of lessons with students’ interest. Moreover, it was found that mathematics was cultural, not neutral as Natesan (2008) pointed out. Follow-up research of a workshop about CRP exposed challenges to expand CRP in mathematics class, which included limited resources and lack of time and space to incorporate CRP. It is also critical to note that the high implementation of CRP increased students’ performance. As mentioned above, Jett (2013) also pointed out the needs of professional development for instructors in college.

Through the findings, it is the most important to note that mathematics is cultural through the research of Carter, Hawkins, and Natesan (2008). In my past experience in Tanzania, it seemed neutral since the contents of the curriculum were much similar to that of Japan. However, the research found that a traditional method of mathematics, which was only a lecture from teacher to students, did not work for students with high verve – this showed that the instruction of mathematics was cultural. Students were alienated from the mathematics classroom due to traditional pedagogy. In terms of professional development, it contributed to increasing the teachers’ awareness of incorporating CRP in class.

It is critical to reveal the situation of professional development in college. Most research collected in this paper focuses on K-12 education, but the two pieces of research that mentioned higher education showed that students face racism in college, which raised attention to the need for protecting them by providing faculty with professional development about CRP. However, it makes sense that students face racism in college as well since faculty in may be dominated by White scholars who do not understand the importance of tenets of CRP.

In terms of conceptual framework, the results of an article from Carter, Hawkins, and Natesan (2008) showed that traditional education methods of mathematics caused low

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expectations, which is one of the opportunity gaps established by Milner (2010). This is because the teachers who practiced that mathematics instruction gave students simple defined questions, which are not expected to be creative and relevant to students' interests and experience. Moreover, the tenets of CRP Gay (2008) provided and its attributes by Ladson-Billings (2009) are related to the research findings. For instance, the key elements required to succeed in mathematics class (Bonner & Adams, 2012) represents empowerment, caring about students, and the connection of the class to students' experiences are matched with tenets such as the development of cultural competence.

There are several limitations to this paper. The first one is that this paper does not reveal to what extent teachers practice CRP in their mathematics classrooms after taking professional development programs. Although the research in this paper mainly focused on specific settings using qualitative methods, the findings of this paper cannot be generalized to other settings. In other words, this paper mainly focused on qualitative research. Therefore, it should not be understood that the findings of this paper represents current situations in mathematics in the U.S. Moreover, subjects in most of the articles were African American students and Latino students. However, it is critical to research other students who are Chinese, Indian, and other students as the number of immigrants has been increasing in the U.S.

Based on the findings and limitations of this paper, it is implicated that more evidence-based research focusing on quantitative analysis is needed to change political conditions (Sleeter, 2012) if CRP is expected to enlarge its impact on more classrooms, schools, districts, states and the U.S. Moreover, this paper demonstrates the importance of professional development. Teachers who practice CRP could improve students' performance at the test. More importantly, it shows the importance of long term or follow-up research to examine the practice of teachers after taking teacher education or professional development courses. It is critical to highlight the practice to achieve equity and make a safe learning space for children. Furthermore, it is critical to provide faculty at universities with professional development that addresses CRP in mathematics classes where minority students face racism.

This paper contributes to understating situations of students, especially those who are African American students and Latino students who are alienated from traditional mathematics classes. Also, it revealed that mathematics is cultural, and professional development can shift teachers' perceptions. Furthermore, the implementation of CRP leads to improving students' performance on a test.

Students of color have struggled to learn mathematics by the "White-centered" pedagogy in mathematics classes. Although professional development has been conducted for teachers to practice CRP in mathematics classes, more support is needed to help these students. Educators including teachers, administrators, and policymakers are required to cooperate to establish a safe space for learning and to achieve equity for students

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