# The Impact of Culturally Responsive Mathematics Teaching on Student Engagement: A Case Study of a Geometry Class

**ACCEPTANCE**

This dissertation, THE IMPACT OF CULTURALLY RESPONSIVE MATHEMATICS TEACHING ON STUDENT ENGAGEMENT: A CASE STUDY OF A GEOMETRY CLASS, by ANU V. KRISHNA, was prepared under the direction of the candidate's Dissertation Advisory Committee. It is accepted by the committee members in partial fulfillment of the requirements for the degree, Doctor of Education, in the College of Education and Human Development, Georgia State University.

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# THE IMPACT OF CULTURALLY RESPONSIVE MATHEMATICS TEACHING ON STUDENT ENGAGEMENT: A CASE STUDY OF A GEOMETRY CLASS

By

**Anu V. Krishna**

Under the Direction of Dr. Christopher C. Jett

## ABSTRACT

Engaging culturally diverse learners (CDLs) in mathematics remains a crucial challenge in U.S. secondary education. This qualitative case study examined the impact of Culturally Responsive Mathematics Teaching (CRMT) on student engagement in a high school geometry class. Grounded in culturally responsive teaching (Gay, 2002; Ladson-Billings, 1995) and informed by the Standards for Mathematical Practice, the study explored behavioral, emotional, and cognitive engagement (Fredricks et al., 2004) as students participated in CRMT-aligned lessons.

Data were collected from eight student participants through semi-structured interviews, lesson reflections, classroom observations, and supporting artifacts. Analysis employed descriptive, emotional, versus, and process coding, refined through constant comparison and

crystallization. Findings revealed that CRMT strategies fostered engagement through four interrelated themes: (a) hands-on activities and group work that sustained participation, (b) opportunities for choice and collaboration that enhanced agency, (c) culturally relevant contexts that promoted confidence and meaningful connections, and (d) supportive relationships and classroom climate that encouraged persistence. Students reported increased confidence, collaboration, and risk-taking when instruction was culturally affirming and connected to real-world applications.

This study contributes to scholarship on culturally responsive pedagogy by illustrating how CRMT can elevate engagement in secondary mathematics while highlighting implications for equity in STEM pathways.

**Keywords:** Culturally responsive mathematics teaching, culturally diverse learners, student engagement, behavioral engagement, emotional engagement, cognitive engagement, Standards for Mathematical Practice, high school geometry, equity in mathematics education, qualitative case study.

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## DEDICATION

This dissertation is dedicated to my husband, Krishna Eechampati, whose unwavering love and support made this journey possible; to my children, Arnith and Anika, and my daughter-in-law, Hyma, whose encouragement and joy gave me strength; to my parents and siblings, for instilling in me the values of perseverance and learning; and to my colleague, Dr. Brian Wynne, for his mentorship and guidance. I also dedicate this work to my beloved dog, Morgan, whose loyal companionship and memory continue to comfort me.

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# CHAPTER 1 INTRODUCTION

*"There are two versions of math in the lives of many Americans: the strange and boring subject that they encountered in classrooms and an interesting set of ideas that is the math of the world and is curiously different and surprisingly engaging."*

(Boaler, 2015, p.5)

*"Diversity provides complexity, depth, multiple perspectives, and equity to relationships, thereby extending human and societal possibilities. If we do not understand each other as equal, in the sense of having something of value to bring to the learning process, we cannot form relationships that contribute to growth and purpose."*

(Lambert et al., 2002, p. xiii)

When discussing mathematics education, we encounter two distinct versions of math that exist in the lives of many Americans. The first version is often taught in classrooms, which can be dull and unengaging. The second version is a captivating realm of ideas that extends beyond academic settings. Boaler (2015) highlights this duality and emphasizes the difference between conventional classroom math and the engaging, intriguing nature of mathematical concepts in the real world. This study examines how Culturally Responsive Mathematics Teaching (CRMT) strategies influenced student engagement in a high school geometry class, attending to behavioral, cognitive, and emotional dimensions and using the Standards for Mathematical Practice (SMPs) as an analytic lens.

Additionally, Lambert et al. (2002) stress the importance of cultural diversity in shaping relationships and unlocking human potential. Their insights underscore the importance of diverse perspectives and equitable contributions in fostering meaningful connections that promote growth and a sense of purpose. This research study examines the impact of CRMT on student engagement among culturally diverse learners (CDLs) in a high school geometry course, with a particular focus on instructional strategies and classroom interactions that foster participation, collaboration, and mathematical reasoning. The study aims to support a local school's efforts to

enhance student engagement, particularly among students from culturally diverse backgrounds, by utilizing culturally responsive teaching (CRT). It aligns with the national push for Science, Technology, Engineering, and Mathematics (STEM) education while promoting diversity in the field. The study underscores the importance of equity in mathematics education and calls for a shift away from traditional teaching methods. Moreover, this investigation aims to provide valuable insights into teaching practices that can benefit both students and educators in creating a more inclusive and effective learning environment. The study aims to identify ways to engage and encourage more students, particularly those from diverse backgrounds, to develop an interest in mathematics and to explore courses and opportunities in STEM fields.

In this chapter, I first examine the relationship between student engagement and mathematical proficiency, considering diverse demographic groups. The following section focuses on the nationwide priority of STEM and the need for better representation, especially among diverse student demographics. The context mentioned above lays the foundation for subsequent discussions. The study advocates moving away from traditional teaching methods and emphasizes the importance of achieving equity in mathematical education. Furthermore, I will share my personal experiences that motivated me to explore CRMT. In the subsequent sections, I will explain the problem, the study's purpose, and the research questions. These sections will emphasize the importance of promoting inclusivity in education.

**Mathematical Proficiency**

Research shows a strong connection between student engagement and proficiency in mathematics (Fredricks et al., 2004). For culturally diverse learners (CDLs), a lack of culturally relevant instruction often contributes to disengagement and lower proficiency (Ladson-Billings, 1997; Marks, 2000). Bonner and Adams (2012) argued that proficiency gaps highlight the need

for instruction that validates CDLs' talents and supports long-term mathematics success, thereby improving future opportunities.

Mathematics is sometimes viewed as a culturally neutral subject; yet scholars have shown that instructional practices often ignore or undervalue the cultural strengths of CDLs. Differentiated and responsive teaching enables diverse students to succeed (Gutiérrez, 2017), while ignoring cultural discontinuity can perpetuate disengagement (Tyler et al., 2008). Prior research urges educators to question inequalities in the educational engagement of CDLs (Hobbs, 2018; Ladson-Billings, 1995; Milner, 2013) and to design mathematics instruction that promotes both access and critical reasoning (Anyon, 2009).

Disproportionate representation of CDLs in advanced courses also signals inequities in mathematics opportunities (Hanselman et al., 2022; Solórzano & Ornelas, 2002). These placement patterns reflect systemic decisions that shape students' access to resources and learning environments. Further research highlights the importance of incorporating students' cultural heritage into mathematics teaching to create more engaging and equitable learning contexts, ultimately supporting both engagement and proficiency.

**National STEM Interest**

STEM gained momentum in the early 2000s due to global competition in science, technology, and workforce development. National reports continue to highlight this urgency: the U.S. Department of Commerce (2022) noted that STEM fields grew by 24.4% over the past decade, compared to 4.0% in non-STEM occupations, and projected continued growth. The U.S. Bureau of Labor Statistics has likewise estimated steady increases in STEM-related jobs (Krutsch & Roderick, 2022). The National Council of Teachers of Mathematics (2023) emphasized the need for strong mathematics preparation to address these demands, while the

National Science Foundation (2018) reported only modest gains in producing STEM graduates relative to national and global needs. Despite policy initiatives such as Educate to Innovate (2009) and Raise the Bar: STEM Excellence for All Students (USDOE, 2022), concerns persist about student readiness for STEM majors, with ACT (2018) data indicating that only 20% of graduates are adequately prepared for the rigors of STEM pathways. While national STEM priorities provide important context, this study focuses on how CRMT influences engagement in high school geometry instruction, with the broader aim of fostering students' sustained interest in mathematics so they may eventually pursue STEM fields and pathways.

**Conventional Mathematics Instruction**

As it stands, public schools' curricula and instructional practices remain predominantly Eurocentric (Acharya et al., 2021). As classroom diversity increases, instructional practices, resources, and opportunities that cater only to the dominant culture will become insufficient to provide the necessary education for all student groups to achieve academic success. Conventional instruction often favors students from Eurocentric backgrounds, excluding the interests and contributions of students from diverse cultural backgrounds, thereby hindering relevance and engagement among CDLs (Boaler, 2008; Darling-Hammond, 2006; Rendon, 1994).

Stodolsky (1988) found that conventional mathematical classrooms are teacher-centered, characterized by whole-class instruction and limited teacher-student interaction, resulting in one-size-fits-all instruction that overlooks students' specific interests and needs. In other work, Silver and Stein (1996) found that the limitations of conventional mathematics education include practices that emphasize memorization without relevance to students' conceptual understanding and reasoning about mathematical concepts, resulting in a lack of active learning participation

among all students. In his work in secondary mathematics classrooms, Schoenfeld (2002) found that there was a greater emphasis on procedural problem-solving techniques (purely numerical) than on real-life application problem-solving relevant to students' cultural backgrounds and everyday living situations. The same study also found lower student engagement with traditional mathematical instruction. Given this academic scenario, it is evident that disengaged students do not reach their fullest learning potential, underscoring the need for culturally relevant instruction to enhance engagement and unlock the academic capabilities of all students.

**Diverse Student Demographics**

According to Oakes (2005), STEM success for CDL requires culturally responsive instructional strategies that cater to the diverse learning needs of students. Educators can mold young minds, either directly or indirectly, by projecting their beliefs about what students can and cannot achieve. Therefore, pausing to examine educators' instructional practices is imperative for determining how fair and inclusive they are. Research can inform policies and standardize pressures to shape feasible educational options, thereby reducing inequalities in mathematics classrooms (Hanselman et al., 2022).

While mathematical practices provide a roadmap to ensure the quality of instruction for all students, educators must fine-tune and differentiate instruction, particularly for students with disabilities (Civil, 2020). Currently, public education is experiencing an increase in students from non-dominant cultures. The U.S. Census Bureau (2022) cites a decrease in the non-Hispanic White population from 64% in 2010 to 59.3% in 2021. Additionally, the U.S. Census Bureau (2022) projects a 43% increase in the number of people of color in the United States by 2025. Further, non-Hispanic White residents are projected to constitute less than half of the U.S. population by 2044 (Colby & Ortman, 2015). These numbers indicate a steady increase in non-

dominant cultures and CDLs in public school enrollments, most notably among students under the age of 16.

Previous studies on learning opportunities and mathematics proficiency levels have consistently shown the existence of long-standing cultural and racial disparities (Johnson et al., 2022; Martin, 2013). For instance, the analysis from the National Assessment of Educational Progress (NAEP, 2022) shows that 26% of White eighth graders scored proficient in mathematics, compared to 9% of Black students. Additionally, 1% of Black students scored as exemplary in mathematics, compared to 9% of White students. Similarly, the U.S. Department of Education (2022) found that 53.2% of White students were enrolled in Advanced Placement (AP) mathematics classes compared to 9.3% of Black students. Hence, there is a strong need for research studies to understand the connection between instructional practices that include and value students' cultural backgrounds and student proficiency in mathematical courses (Mintos et al., 2018). As an emerging mathematics education researcher, I suggest using asset-based recommendations to promote and implement Diversity, Equity, and Inclusion (DEI) strategies.

These strategies should reflect the diverse population in the United States and help CDLs succeed in mathematics courses. Recent studies have highlighted the importance of using such strategies to advance DEI in STEM fields and to foster a sense of belonging and engagement for CDLs in mathematics classrooms (Carter et al., 2021; Espinosa, 2021; Johnson et al., 2022).

**Equity and CRMT: Aligning with NCTM's Vision**

Mathematics has traditionally held a distinctive status among academic subjects, often perceived as a universal, abstract, and objective discipline (Ernest, 1999). However, this notion of neutrality is misleading. Nasir (2016) argues that mathematics instruction should not aim for

culturally neutral or universal approaches. Ernest (1999) offers an alternate view, suggesting that mathematics is inherently shaped by human activity and societal context.

Equity in mathematics education refers to providing all students, regardless of their background or identity, with equal opportunities to learn and succeed. Given that mathematics is foundational to STEM disciplines and access to STEM careers, equity in mathematics education is critical (Herman, 2019). Suazo-Flores et al. (2020) emphasize that equity means ensuring that all students have opportunities to engage meaningfully with and succeed in mathematics.

Despite numerous studies identifying strategies to support success, gaps in mathematical proficiency persist between culturally diverse learners (CDLs) and their White peers (NCTM, 2014). These persistent disparities highlight the need to strengthen equity in mathematics education (Bonilla-Silva, 2010; Civil, 2020).

Scholars argue that educational institutions must promote equity, as students from non-dominant cultures are often disadvantaged by traditional instructional approaches (Civil, 2020; Tate, 1995). Inclusive pedagogies, particularly Culturally Responsive Teaching (CRT) practices, offer viable pathways to promote equity for CDLs. Connecting mathematics instruction to students' cultural experiences can deepen understanding and increase engagement (Acharya et al., 2021). Research supports practices such as using culturally relevant examples, embedding everyday problem contexts, and aligning teaching practices with curriculum reforms to enhance conceptual understanding and support success (Boaler, 2008; Gutstein et al., 1997; Tate, 1995).

Suazo-Flores et al. (2020) further argue that promoting equity goes beyond achievement. It involves ensuring access to high-quality instruction, cultivating positive mathematical identities, and empowering students to express their ideas freely. However, achievement

disparities across racial and ethnic groups persist, despite systemic and policy reforms, indicating that more culturally responsive, equity-driven strategies are needed in practice.

This study adopts a CRMT framework that prioritizes students' cultural knowledge and classroom contributions, recognizing equity as a guiding principle rather than a coded outcome. Although equity was not directly coded as an outcome, it remained foundational to the study and was embedded in the CRMT framework, guiding the design of lessons and instructional practices.

The National Council of Teachers of Mathematics (NCTM, 2022) emphasizes the importance of equity in ensuring that all students experience high-quality mathematics instruction. According to NCTM:

> Acknowledging and addressing factors contributing to differential outcomes among groups of students is critical to ensure that all students routinely have opportunities to experience high-quality Mathematics instruction, learn challenging Mathematics content, and receive the support necessary to succeed. Addressing equity and access includes both ensuring that all students attain Mathematics proficiency and increasing the number of students from all racial, ethnic, linguistic, gender, and socioeconomic groups who attain the highest levels of Mathematics achievement (p. 1).

NCTM's vision aligns with the goals of this study by calling for equitable learning environments that support diverse learners in achieving excellence. Similarly, Ladson-Billings (1995) posits that equity pedagogy benefits all students, and the unequal distribution of resources often leads to inequitable outcomes. The Association of Mathematics Teacher Educators (AMTE, 2022) echoes this stance, defining equity through principles of access, inclusion, respectful interaction, and fairness.

Thus, incorporating equity into instruction, while not a formally coded construct in this study, is central to the CRMT framework that guided lesson design and classroom practice. This emphasis ensures that all students have a meaningful opportunity to succeed in mathematics and contribute to a more just and inclusive learning environment.

**Personal Connection to the Research Study**

The Ed.D. program at Georgia State University (GSU) provided me with insight into evaluating and incorporating cultural aspects to create meaningful and motivating mathematics lessons that reach students from diverse cultural backgrounds and with diverse learning needs. I teach high school mathematics classes, namely, precalculus and geometry. To understand the diversity of the classes, I asked my students about their cultural traditions, preferred ways of learning mathematics, and their intentions regarding pursuing a STEM-related career. I hoped that themes would emerge to help me categorize and organize mathematics lessons, aiding my efforts in incorporating students' diverse learning needs. I was immensely proud to have conceived an idea that delivers powerful lessons. Students produced diverse learning preferences for mathematics, and some had interesting cultural backgrounds. Except for a few students, the majority struggled to grasp the practical applications of mathematics in real life or expressed intimidation, citing a lack of coherence in their understanding. Consequently, they expressed hesitation about pursuing STEM careers or were uncertain about the connection between mathematics and STEM fields.

The assignment made me realize the diversity among my students in terms of cultures, socioeconomic backgrounds, and varied learning needs. The assignment also shed light on my students' intimidation and lack of coherence in connecting mathematics, prompting consideration of careers that involve mathematical skills. In previous years, without the

knowledge and understanding of instructional practices incorporating cultural teaching, I started the class every day with a similar routine. I took pride in how well-organized and challenging my classes were. However, every year I face the same dilemma, failing to connect with all students despite my well-prepared lessons. Although creativity and differentiation in my instruction sparked students' enthusiasm, they only took notes. There were a few classroom discussions and little student interaction. They needed more continued focus and engagement with the lesson. Consequently, the sessions for extra help, held before and after school, were always full. The students' anxiety, disappointment, and frustration were evident before exams due to their inadequate understanding of the lesson. Consequently, their participation decreased, and the students' mathematical proficiency remained minimal.

As an Indian woman pursuing my education in the United States, I have faced similar issues to my classroom students in finding relevance in instruction. Furthermore, my interactions with my class were limited, resulting in missed opportunities for valuable learning through collaboration. Hence, my personal experience as a student motivates me to employ instructional strategies that provide numerous learning opportunities for my students and create a classroom environment that supports their diverse learning needs, thereby enhancing their engagement, collaboration, learning, and proficiency in mathematics.

Aside from careful planning, several factors contribute to a lesson's success (Gay, 2002). After reviewing the results of the first-day assignment, I realized the importance of creating lessons tailored to my students' needs. My efforts to tailor my teaching to students' individual learning preferences and my interest in incorporating different perspectives into teaching have led me to explore CRMT strategies for my dissertation research.

As a dedicated mathematics educator, I am committed to promoting social justice in my teaching practices. I believe in adopting pedagogies and frameworks that go beyond one-size-fits-all models. I have learned to integrate culturally related pedagogies and frameworks such as Culturally Relevant Pedagogy, Culturally Responsive Pedagogy, and frameworks of CRT and CRMT to transform my instructional approach. CRT has helped me understand the diversity of my students and consider their identities in instructional planning. I have recognized that making mathematical instruction overly broad under the guise of equality leverages factors contributing to the inequalities related to the learning and teaching of CDL (Nasir, 2016).

My goal is to enhance the mathematical understanding and learning of CDLs and foster a safe and supportive learning environment. The work of scholars such as Bonner (2014), Gay (2002), and Tate (1995) has heavily influenced my approach.

Regarding how my personal background may influence my current research, I understand the importance of acknowledging and critically reflecting on my positionality, which includes my background, experiences, and biases that may impact the research process. To achieve reflexivity as a researcher, I need to be aware of potential biases and actively work to avoid them. As an immigrant, I have unique insights and experiences related to different cultures. However, I must also be careful not to overlook the rich diversity of other cultures represented in the classroom and avoid any unintentional biases.

Reflexivity is not a one-time task but a continuous process. Throughout the research process, I will persistently examine my assumptions, biases, and perspectives. This self-awareness will empower me to actively seek diverse perspectives, challenge preconceived notions, and ensure that research efforts are inclusive and culturally sensitive. The works of Tracy and Hinrichs (2017) and Guillemin and Gillam (2004) have highlighted the importance of

engaging in reflexivity as a researcher. These commitments informed me of my reflexive stance throughout the study, as detailed further in Chapter 3.

**Statement of the Problem**

The problem addressed in this study is the persistent disengagement of CDLs in mathematics classrooms, where conventional instruction often fails to connect with students' cultural experiences. Despite national efforts to broaden participation in rigorous mathematics, disengagement continues to limit access and confidence. This lack of CRMT represents a critical gap that contributes to disengagement and underrepresentation in advanced mathematics. This study examined how CRMT strategies may foster student engagement in high school geometry, focusing on instructional moves that validate culture, promote collaboration, and connect mathematics to students' lives.

Furthermore, Dancy et al. (2020) have raised concerns about enrollment patterns and the underrepresentation of CDL students in STEM courses. This is a critical issue that requires prompt attention and decisive action. The talents of CDL students should be utilized wisely, as the field of mathematics shapes technology and who develops it (Apple, 2018). STEM is growing rapidly, but practitioners in this field must be diverse and represent all groups proportionately (Darling-Hammond, 2006). Therefore, this study directly addresses the problem of disengagement by investigating how CRMT can serve as a tool to bridge the gap between culture and mathematics learning. This study aims to investigate the impact of using CRMT on student engagement, classroom participation, and mathematical understanding in a culturally diverse high school geometry class. In doing so, this study is grounded in the belief that engaging instruction not only enhances learning outcomes but also serves as a gateway for historically underrepresented students to pursue future success in STEM fields.

## Purpose of the Study

The purpose of this qualitative case study was to investigate how CRMT strategies influenced student engagement among CDLs in a high school geometry class. Engagement was examined across behavioral, cognitive, and emotional dimensions, with the SMPs serving as a lens for analysis. Evidence for these dimensions was drawn qualitatively from student interviews, classroom artifacts, and researcher observations.

Student engagement has become a top priority in my school and county following the COVID-19 pandemic, as academic engagement and motivation have declined significantly. Teachers are encouraged to utilize strategies that enhance engagement in daily lessons, with a particular focus on STEM exposure and culturally responsive instruction to prepare students for college-level programs. As such, CRMT and CRT have been shown to improve engagement and learning outcomes (Yonezawa et al., 2009).

This investigation focused on how CRMT instructional strategies supported students' participation, collaboration, and confidence in mathematics learning. This focus is crucial for encouraging students to pursue mathematics and consider careers in STEM fields. As an educator from a culturally diverse background, I have observed instances of intimidation and disconnection from mathematics among my students, particularly those from culturally diverse backgrounds. Therefore, this study examined how CRMT can enhance engagement, confidence, and participation for CDLs in mathematics.

## Research Questions

The research study investigated CRMT practices to engage CDLs in a high school geometry class and examine engagement through the SMPs. Guided by the CRT and CRMT frameworks, the study on mathematics education investigates the following questions:

1. How did integrating CRMT in a high school geometry class impact student engagement during instruction and in-class activities, which promoted the SMPs?
2. How do students describe the impact of CRMT-based instruction on their engagement and learning in a geometry class?

**Significance of the Study**

Contemporary classrooms are becoming increasingly diverse in terms of cultural backgrounds, linguistic styles, and learning preferences. Educators must develop the necessary skills to adapt their teaching methods to meet the needs of diverse learners (Hubert, 2014). Educators must prepare students for 21st-century demands (e.g., critical thinking, creativity) and design culturally responsive instruction tailored to students' needs (Bonner & Adams, 2012; Cholewa et al., 2012). By increasing student engagement and confidence in mathematics, my research also aims to address underrepresentation in STEM pathways, encouraging more students from diverse backgrounds to view themselves as capable of succeeding in mathematics-related careers (Boaler, 2016; Martin, 2000). These outcomes are crucial for expanding access to STEM education and enabling historically underrepresented students to envision themselves in math-related academic and career pathways.

Educators must adapt content and methods to CDLs' learning needs, as engagement varies across cultural, racial, and social lines (Gutiérrez & Dixon-Román,2011; Ladson-Billings, 2005). However, teacher preparation programs and professional development opportunities rarely provide teachers with opportunities to reflect on their practices and biases, thereby hindering their ability to support CDLs (Gay, 2002; Hobbs, 2018; Ladson-Billings, 2014).

Student-centered instruction that incorporates students' interests and backgrounds, with teachers as facilitators, makes activities more compelling (Tate, 1995). Gutiérrez (2000) explains

identity as a metaphor, stating that students need to see themselves reflected in the curriculum (as a mirror) as well as have a view of the broader world (through a window). This metaphor describes the balance between self and mathematics relevant to students' learning. Mathematics educators should draw on students' cultural and linguistic resources in instructional decisions (Gutiérrez, 2017; Mintos et al., 2018)

Previous studies have highlighted the importance of examining how cultural influences impact mathematical reasoning and understanding (Leonard et al., 2010; Malloy et al., 1998). Gay's (2013) CRT framework offers strategies for incorporating students' cultures into everyday lesson plans, using their prior knowledge, cultural knowledge, and performance styles to make instruction relevant. Research also suggests that students participate more actively in classroom discussions when lessons are engaging and relevant (Appleton et al., 2008; Fredricks et al., 2004; Marks, 2000).

This study provides tangible evidence from a high school geometry context that culturally responsive lessons enhance student engagement among CDLs. The findings will serve as a valuable resource for educators and school leaders, providing concrete insights into CRMT strategies that promote student participation, foster mathematical confidence, and enhance instructors' cultural responsiveness. Although this study focuses specifically on student engagement, the findings may inform broader efforts to reduce disparities in STEM education by highlighting instructional practices that support culturally diverse learners. Ultimately, this research reflects a broader goal of ensuring that historically underrepresented students not only engage with mathematics but also envision themselves thriving in STEM pathways, where their perspectives are critically needed.

This dissertation is structured into five chapters. Chapter 1 outlines the study's background, problem, purpose, and research questions. Chapter 2 reviews the literature on CRMT, student engagement, and the SMPs that frame this research. Chapter 3 describes the qualitative case study methodology and data collection procedures. Chapter 4 presents the findings organized through thematic analysis, and Chapter 5 discusses interpretations, contributions, and recommendations for practice and future research.

**Definition of Key Terms**

- *Student Engagement:* The level of involvement, commitment, and enthusiasm that students bring to the classroom and learning (Fredricks et al., 2004).
- *Culturally Responsive Teaching*: A teaching approach that recognizes, integrates, and values students' cultural backgrounds and experiences to promote educational equity (Delpit, 1988; Gay, 2013; Ladson-Billings, 1997).
- *Culturally Responsive Mathematics Teaching*: Instructional practices in mathematics that incorporate students' cultural experiences and backgrounds to promote academic achievement and address cultural biases and inequalities (Gutiérrez, 2017).
- *Standards for Mathematical Practice:* The SMPs provide mathematics educators with the instructional skills required to develop mathematical proficiencies in their students for long-standing mathematical education (NCTM, 2023; NGA & CCSSO, 2010).
- *Culturally Diverse Learners*: Students from diverse ethnicities, races, gender categories, socioeconomic statuses, and social and cognitive developments, as well as students from diverse cultural backgrounds and home environments other than the mainstream culture (Hall et al., 2014).

- *STEM (Science, Technology, Engineering, and Mathematics):* An academic and career pathway encompassing scientific, mathematical, and technological disciplines. The field has been a national focus for increasing innovation and addressing workforce diversity (NSF, 2018; USDOE, 2022).

# CHAPTER 2 LITERATURE REVIEW

In today's diverse educational environments, it is essential to recognize and respond to students' cultural backgrounds to foster inclusive and effective classroom practices. This approach, known as Culturally Responsive Teaching (CRT), is grounded in the principle that leveraging students' cultural identities fosters academic success (Gay, 2000; Ladson-Billings, 1995; Nieto, 2002).

This chapter presents a literature review at the intersection of CRT and mathematics education, with a particular focus on engaging culturally diverse learners (CDLs) in high school geometry and improving their representation in STEM fields. The review begins by examining the concept of student engagement, especially its significance in culturally diverse classrooms. It then explores how Culturally Responsive Mathematics Teaching (CRMT) can serve as a framework to promote meaningful participation and academic growth for CDLs.

In addition to synthesizing key theoretical and empirical research, this chapter highlights gaps in current understanding, particularly in how CRMT influences engagement and participation in secondary mathematics classrooms. The review also assesses the consistency and limitations of existing research, providing a nuanced perspective on how responsive teaching practices can promote equity, inclusion, and sustained engagement in mathematics education.

## Student Engagement

The term student engagement entered educational literature in the 1980s and has since become widely used among educators, researchers, students, and policymakers. However, it continues to be interpreted in various ways (Wong & Liem, 2021; Yazzie-Mintz, 2006). Student engagement, a multifold concept, involves both in-class and out-of-class activities that collectively lead to observable learning outcomes (Alrajeh & Shindel, 2020). Trowler (2010)

suggested that student engagement is characterized by active involvement in school-related activities, which leads to positive academic outcomes. Additionally, Hu and Kuh (2001) defined student engagement as the level of effort students invest in academically purposeful activities, noting that intrinsic motivation drives both intellectual and emotional commitment, extending well beyond superficial participation.

In mathematics education, engagement extends beyond skill development; it also influences students' attitudes, confidence, and long-term interest in the subject. Previous research highlights the vital link between high levels of student engagement and their overall success in mastering math skills, emphasizing the importance of effective strategies to promote this engagement (Boaler, 2008; Deborah, 2012). Engaging students in mathematics has been shown to boost their academic performance and help them develop problem-solving skills that are crucial in many areas of life. Recent studies also confirm that culturally and socially responsive instruction can enhance persistence and conceptual understanding, especially for secondary math learners (Suh & Calabrese, 2025; Tran et al., 2022).

Fredricks et al. (2004) and Yazzie-Mintz (2006) revealed a positive correlation between student engagement and academic success. Student engagement was fostered when class members actively discussed ideas, debated various viewpoints, and critiqued each other (Fredricks et al., 2004). Marks (2000) explained, "Engagement in the classroom leads to achievement and contributes to students' social and cognitive development" (p. 154). The lack of student engagement, as observed in low academic accomplishments and school dropout rates (Fredricks et al., 2004), is often accompanied by boredom, disinterest, and a perception of irrelevance (Yazzie-Mintz, 2006).

Daily instruction tailored to students' understanding and interests can enhance their engagement. According to Fredricks et al. (2004), student engagement has three dimensions. The first dimension is behavioral engagement, which includes following school rules, attending classes, and actively participating in class activities. The second dimension is emotional engagement, which involves students' affective experiences, including their interest in school subjects, learning processes, emotional connections to the school environment, and feelings of belonging. Emotional engagement also considers students' emotional reactions during learning, including interest, boredom, happiness, sadness, and anxiety (Yonezawa et al., 2009). The third dimension is cognitive engagement, which focuses on students' passion for learning. This dimension goes beyond foundational learning and seeks challenges to master the subject matter.

Researchers have linked the cognitive aspect of student engagement to the motivational process and the use of metacognitive strategies (i.e., thinking about and managing one's thinking process) (Ciric & Jovanovic, 2016). Kong et al. (2003) assessed cognitive engagement through learning strategies, behavioral engagement through attentiveness and mathematical intelligence, and effective engagement through metrics such as interest in exam orientation and frustration. This endeavor validated three constructs of student engagement, each creating unique content within the context of mathematics.

Ciric and Jovanovic (2016) explored cognitive, social, and emotional engagement through learning strategies, group dynamics, and value systems. In their study, Klemenčič and Chirikov (2015) examined student engagement by analyzing observable behaviors influenced by institutional cultures, family support, and student emotions. They found that student engagement follows a linear relationship, in which curriculum design has a direct influence on learning engagement.

Teachers can encourage students' passion for learning by providing challenging opportunities to master the subject matter. Daily instructions tailored to students' needs and interests can enhance their academic success and engagement in the subject matter. The goal of measuring the distinctive dimensions of student engagement is to enhance learning and invest in students' future development. Engagement encourages learning that requires effort and energy; all students can achieve it regardless of their socioeconomic background or learning needs (Ciric & Jovanovic, 2016). In CRMT-based classrooms, this connection is vital, as culturally relevant instruction reinforces students' sense of purpose and belonging (Gay, 2018; Mamedova & Orosco, 2024).

Contemporary research employs a multidimensional approach, utilizing two or three dimensions, such as behavioral, emotional, or cognitive engagement, as indicators of student engagement (Appleton et al., 2008; Fredricks et al., 2016). Enhancing engagement strategies contributes to a positive school experience and motivation at all education levels. Learning strategies should align with active participation and different teaching and learning circumstances. Some effective teaching practices include designing meaningful learning experiences, fostering relationships among peers and teachers, and utilizing assessments for guidance (Taylor & Parsons, 2011). Students were encouraged to participate in the teaching process, fostering creativity in problem-solving, research, projects, collaborations, and group work (Taylor & Parsons, 2011).

Schussler's (2009) research investigated classroom management strategies used to enhance the intellectual engagement of disengaged students. The author posited that teachers foster an environment conducive to intellectual engagement when students (a) perceive opportunities for success, (b) encounter flexible learning paths, and (c) feel respected as learners

due to teachers' beliefs in their capabilities. Effective classroom management that optimally combines these elements results in students feeling recognized and valued. When teachers appropriately challenge students, offer academic support, employ instructional methods that convey enthusiasm for the subject matter, and make learning relevant, they create an intellectually engaging classroom environment.

Experts believe student engagement is crucial in fostering a deep and long-lasting understanding of mathematical concepts in education. The NCTM has outlined rigorous standards for every K-12 student, emphasizing the importance of equity, high expectations, and dedicated support for all students. Students should engage in mathematics through specific practices to attain a profound mathematical understanding. The NCTM provides principles that serve as the foundation of instructional strategies. These principles align with the SMPs, which provide educators with comprehensive guidelines that influence teaching approaches and offer a structured framework for evaluating student involvement. Educators can utilize the SMPs to obtain comprehensive guidelines for effectively assessing student engagement. These standards provide a foundation for examining how CRMT can leverage SMPs to enhance student engagement, particularly among culturally diverse learners.

**Standards for Mathematical Practice**

The SMPs are integral components of the Common Core State Standards for Mathematics (CCSSM), a research-based framework developed by the Council of Chief State School Officers and the National Governors Association [NGA & CCSSO] (2010) to promote mathematical proficiency across K–12 education (NGA & CCSSO, 2010). These standards were developed to assist educators in modifying and aligning mathematics content to promote advanced mathematical understanding and to provide clear and consistent mathematical goals for

students across the country, thereby further improving STEM progression among K–12 students. It offers a shared framework to guide students toward mathematical proficiency. While the CCSSM outlines grade-specific content standards to ensure college and career readiness, the eight SMPs provide pedagogical guidance that fosters consistency, depth, and rigor in instruction.

The NCTM (2000) also published a set of inquiry-based standards that provide mathematical instructional practices for educators, outlining the elements of mathematical proficiency of content and process standards. The content standards include problem-solving, reasoning, communication, connections and representations, conceptual understanding, procedural fluency, competency, adaptive reasoning, and productive dispositions. While CCSSM focuses on grade-specific K-12 learning objectives and expectations, NCTM standards provide mathematical guiding frameworks with a comprehensive approach to teaching mathematics. CCSSM and NCTM emphasize the relevance and real-world connections and contexts to students (NGA & CCSSO, 2010). Based on the categories mentioned above, the SMP consolidates the practices into eight practices that students should be encouraged to follow:

1. **Make sense of problems and persevere in solving them**. This standard promotes resilience and encourages students to understand that problem-solving is a process.
2. **Reason abstractly and quantitatively**. This standard connects mathematical concepts to real-world situations, enabling students to better understand the relationship between abstract ideas and concrete scenarios.
3. **Construct viable arguments and critique the reasoning of others**. This standard develops students' capacity to articulate their mathematical thinking clearly and engage in constructive discussions to deepen their understanding.

4. **Model with Mathematics**. This standard emphasizes the application of mathematical models to solve practical problems. It promotes a hands-on, real-world approach to mathematical understanding.

5. **Use appropriate tools strategically**. This standard instills the habit of effectively selecting and using various mathematical tools, whether physical manipulatives or digital resources, to enhance problem-solving.

6. **Attend to precision**. This standard stresses the importance of precision in mathematical communications and calculations. It promotes accuracy and clarity in conveying mathematical ideas.

7. **Look for and make use of the structure**. This standard encourages students to identify and utilize patterns and structures in mathematical problems, thereby fostering a deeper comprehension of underlying principles.

8. **Look for and express regularity in repeating reasoning**. This standard guides students to recognize repetitive patterns and use this understanding to generalize. It promotes a more effective and strategic approach to problem-solving (NGA & CCSSO, 2010).

In culturally responsive mathematics classrooms, the SMPs align well with CRMT goals, as they encourage mathematical reasoning, discourse, and problem-solving strategies that can be adapted to students' cultural backgrounds and lived experiences (Jackson et al., 2021; Suh & Calabrese, 2025). Aligning learning objectives with students' interests is crucial to enhancing student engagement (Ciric & Jovanovic, 2016). Student engagement involves a dynamic interplay between initiative-taking involvement, intrinsic motivation, and a genuine drive to excel academically. This study examines cognitive engagement in mathematics and identifies key factors that impact learning outcomes. The study highlights the crucial role of student

engagement in promoting effective CRT practices in mathematics education. The following section discusses the implications of student engagement in CDL for mathematics education.

**Student Engagement and Culturally Diverse Learners**

Student engagement has become a cornerstone of effective pedagogy in today's educational landscape. However, its significance is heightened when considering CDLs. The multicultural nature of the classroom demands a nuanced approach to teaching that goes beyond the conventional one-size-fits-all method (i.e., a standardized approach that treats all students uniformly, disregarding their diverse learning needs). Tailoring instructional strategies to engage CDLs supports both meaningful learning and the development of their identity. CRMT practices that affirm students' cultural knowledge and lived experiences have been shown to foster a sense of belonging and engagement in mathematics classrooms (Charles, 2015; Mamedova & Orosco, 2024).

Charles (2015) investigated the impact of enhancing academic progress through student engagement by utilizing culturally responsive instruction. The study revealed that a crucial element for involving students in creating a positive learning environment and establishing connections within their learning community was recognizing and valuing students' diverse experiences and knowledge. Charles further argued that students do not come to school as blank slates. When educators affirm students' backgrounds and incorporate them into instruction, they foster motivation and academic success.

Engaging CDLs involves more than just delivering content; it requires establishing genuine connections between academic subjects and students' diverse backgrounds (Berry, 2008; Gay, 2002). Incorporating diverse examples, references, and case studies makes learning more meaningful. When students see their own heritage and life experiences reflected in the

curriculum, the content becomes not only more accessible but also more engaging (Banks, 2016; Gay, 2002; Nieto, 2002). A core principle of student engagement is ensuring that all learners feel included and valued. Culturally diverse classrooms include a wide range of learning styles, languages, and perspectives.

CRT practices acknowledge these differences and create an environment where every student can participate meaningfully and feel a sense of ownership over their learning (Hammond, 2015; Ladson-Billings, 1997). Engaging CDLs extends beyond academic participation and affirm students' identities. Recognizing and celebrating diverse cultures in lessons has a positive influence on students' self-worth and sense of belonging (Byrd, 2021; Schussler, 2009). This sense of validation fosters long-term academic empowerment and personal growth (Bonner & McGee, 2022; Schussler, 2009). The empowerment that results from this extends beyond the classroom, shaping CDLs' self-perception, purpose, and aspirations.

Engagement strategies that promote active participation and open dialogue are transformative in culturally diverse settings. Stinson et al. (2023) found that when instructors implemented culturally relevant pedagogy in undergraduate math classrooms, even in settings where the belief that "mathematics has no culture" prevailed, they significantly increased student participation and critical discourse by acknowledging students' cultural identities. These methods create a safe space where students can share their unique perspectives, experiences, and viewpoints. By implementing strategies centered on cultural relevance, inclusiveness, and validation, educators empower students to become active, confident learners who recognize the importance of diversity both inside and outside the classroom (Fredricks et al., 2004; Hammond, 2015). A widely recognized framework for understanding student engagement is the tripartite model developed by Fredricks et al. (2004). This model conceptualizes engagement comprising

behavioral, emotional, and cognitive aspects, offering a multidimensional lens for analyzing how students participate in and connect with classroom learning. Behavioral engagement refers to observable participation, such as attending class, completing assignments, collaborating with peers, and persisting with challenging tasks. Emotional engagement reflects affective dimensions of learning, including students' interest, sense of belonging, enjoyment, or frustration within the classroom context. Cognitive engagement captures students' investment in learning and their willingness to exert effort, seek challenge, and engage in higher-order problem-solving and reasoning.

This multidimensional framework has been widely applied in educational research to interpret how instructional practices shape students' motivation and participation (Christenson et al., 2012; Quin, 2017). Although often used in quantitative studies, the three dimensions of engagement also serve as effective qualitative analytic categories for examining how learners interact with content, peers, and teachers. For this study, Fredricks et al.'s (2004) framework provided a structured way to interpret evidence of engagement within classroom artifacts, student interviews, and researcher observations. By defining engagement across behavioral, emotional, and cognitive dimensions, the framework facilitated a more nuanced analysis of how culturally responsive mathematics teaching (CRMT) strategies influenced students' participation and their geometry connections. In doing so, educators not only foster critical thinking and collaboration but also nurture intercultural understanding (Appleton et al., 2008; Skinner & Pitzer, 2012). This skill is invaluable for culturally diverse students navigating a world filled with different challenges. Active engagement encourages them to explore new ideas, analyze different viewpoints, and solve problems creatively, skills that extend beyond the classroom into their personal and professional lives (Appleton et al., 2008; Hu & Kuh, 2001; Skinner & Pitzer,

2012; Stinson et al., 2023). By emphasizing engagement among culturally diverse students, educators promote educational equity. This dedication ensures that all students, regardless of their cultural background, receive instruction tailored to their needs and strengths, promoting both academic excellence and social justice (Vavrus, 2008).

Student engagement in mathematics classes, a part of STEM education, is critical for student development (National Research Council, 2011). Students from culturally diverse backgrounds participating in culturally relevant STEM learning are more likely to understand scientific concepts, engineering principles, and technological applications (Selcen Guzey & Aranda, 2017). Engaged students who thrive in mathematics are more likely to apply their knowledge and skills to real-world problems, fostering innovation and creativity (National Research Council, 2011). Furthermore, culturally responsive engagement strategies can help diversify the STEM pipeline, increasing the participation of historically underrepresented groups in higher education and STEM careers (NASEM, 2022).

Developing such transcultural competence is essential for students navigating an increasingly interconnected and diverse world. By tailoring engagement strategies to incorporate cultural relevance, inclusivity, and validation, educators empower students to become active, confident learners who appreciate the value of diversity both within and outside the classroom (Fredricks et al., 2004).

## Gaps in Student Engagement Research

### 1. Conceptual Inconsistencies in Defining Student Engagement

Although engagement is widely recognized as crucial to student success, researchers continue to grapple with inconsistent definitions. Some frameworks view it as behavioral participation, while others emphasize emotional or cognitive investment (Appleton et al., 2008;

Fredricks et al., 2004). This conceptual ambiguity makes it difficult to compare findings across studies or establish robust, unified strategies for fostering engagement, especially for culturally diverse learners (Bond et al., 2020; Sáinz et al., 2022).

**2. Limited Models for Engagement in STEM for CDLs**

Despite increasing recognition of the importance of engagement in STEM, few models are specifically designed to address the needs of culturally diverse learners (CDLs) in high school settings. Much of the existing research focuses on general student populations or early childhood education, leaving a gap in understanding how engagement strategies work in advanced math and science courses for historically underrepresented students (Charity et al., 2017; Hall & Miro, 2016). High school mathematics, especially geometry and algebra, remains underrepresented in engagement studies, despite being a known gatekeeper for future STEM success (Boaler, 2016).

**3. Understudied Engagement in Youth-Centered, Culturally Relevant STEM Activities**

While emerging research shows the promise of culturally responsive and youth-centered STEM programs, most studies remain small-scale and lack long-term follow-up. For example, Barajas-Salazar et al. (2025) found gains in STEM identity through culturally responsive engineering projects. Similarly, the CReST pilot (Ferri & White, 2024) and CRED studies indicate improvements in motivation and performance when culture is explicitly integrated. However, research rarely explores how such approaches translate into sustained engagement, especially in rural or suburban high school settings.

**4. Need for Comprehensive, Scalable Frameworks**

Although national models, such as the Double Check framework (Bradshaw & Rosenberg, 2018; Hershfeldt et al., 2009) and culturally responsive self-regulated learning

approaches (Anyichie & Butler, 2018; Anyichie et al., 2023), show promise, the field lacks scalable, evidence-based frameworks that embed cultural responsiveness into student engagement, particularly in high school mathematics. Much of the current literature relies on large-scale initiatives or generalized programmatic outcomes, while overlooking how culturally responsive mathematics teaching (CRMT) is enacted and experienced in real classroom settings.

This gap underscores the importance of case study research that examines student engagement through the lens of CRMT in specific school contexts. A localized approach offers a nuanced understanding of how engagement strategies unfold in day-to-day instruction and how students, especially those from culturally diverse backgrounds, interpret and respond to these practices. This study contributes to the field by providing an in-depth examination of how culturally responsive engagement manifests in a high school geometry classroom, thereby helping to bridge the gap between theory, policy, and authentic classroom practice. These gaps underscore the need for localized case study research, such as the present study, which examines how CRMT fosters behavioral, cognitive, and emotional engagement in a high school geometry classroom.

**5. Minimal Student Voice in Engagement Research**

Many studies on engagement highlight academic outcomes or teacher practices, but fewer focus on the voices of students themselves, especially those from culturally and linguistically diverse backgrounds (Korpershoek et al., 2020; McKinney de Royston et al., 2021). Student perceptions of what encourages or hinders their engagement are vital for developing effective and inclusive practices. To fully understand student engagement, it is important to examine reflections, classroom interactions, and student work, elements that reveal insights beyond what traditional measures capture.

### 6. Lack of Integration Between Engagement, Equity, and Identity in Math

Engagement research in mathematics often isolates academic participation from broader cultural and identity-based factors. However, CRMT emphasizes that student identity, cultural validation, and agency are inextricably linked to how students engage (Esmonde et al., 2020; Nasir et al., 2014). A theoretical and practical gap remains in understanding how engagement intersects with equity, particularly in rigorous content areas such as high school geometry.

Given these persistent gaps, especially in how engagement is conceptualized, experienced, and supported among diverse learners in mathematics classrooms, there is a critical need to reexamine instructional practices through a more inclusive lens. CRT offers a compelling framework for rethinking both instruction and engagement by centering students' identities, validating their experiences, and fostering deeper connections between learners and mathematical content.

## Culturally Responsive Teaching: Historical and Conceptual Foundations

This study aims to engage culturally diverse learners in mathematics through the implementation of CRT. This instructional approach emphasizes the use of students' cultural backgrounds, experiences, and learning styles to make learning more meaningful and effective. CRT, which focuses on building cultural competence and validating students' lived experiences, emerged from the broader tradition of multicultural education. While multicultural education is rooted in equity and the inclusion of diverse cultural perspectives, CRT emphasizes instructional strategies that affirm students' identities and foster academic success through culturally responsive materials and practices.

The roots of CRT can be traced to the civil rights movement of the 1950s and 1960s, a time marked by advocacy for equity and justice for historically marginalized communities

(Martin, 2013). Recognizing systemic disparities in education and society prompted educators and scholars to seek solutions (Deborah, 2012; Vavrus, 2008). CRT evolved over decades of scholarship, introducing multiple frameworks, including culturally responsive education, culturally relevant pedagogy, and culturally congruent teaching, each offering distinct pedagogical emphases shaped by sociopolitical and educational contexts (Muñiz, 2019). Muñiz (2019) noted that these frameworks vary in emphasis and reflect shifts in sociopolitical and educational contexts. In short, CRT is a pedagogical approach that addresses the need for inclusive and equitable education.

In the late 20th century, Gloria Ladson-Billings advanced the concept of culturally relevant pedagogy (CRP), emphasizing the integration of students' cultural identities into classroom instruction, particularly in mathematics. Ladson-Billings' (1995b) culturally relevant pedagogy incorporated real-life examples, diverse perspectives, and culturally relevant materials that connected mathematics to students' everyday lives. Her work emphasized the importance of understanding and integrating students' cultural identities and backgrounds in the learning process. She argued that educators must honor students' cultural backgrounds as assets that enhance both engagement and learning.

Banks (2001) was a prominent scholar who made significant contributions to the development of multicultural education. He strongly advocated for the inclusion of diverse perspectives and cultures in the curriculum, and his work played a vital role in shaping the principles of critical race theory. Banks (2016) further explained that culture is shaped by language, social rules, and values, which influence how individuals express their values through individual experiences. He proposed a multi-dimensional concept of equity in education, outlining five interactive dimensions of multicultural education, which are described in

subsequent paragraphs. When culturally responsive teachers integrate these dimensions into their teaching practices, they can nurture informed and democratic citizens.

Banks (2001) conceptualized the first dimension of content integration as an instructional approach that involves presenting subject matter from diverse cultural perspectives. This approach challenges dominant models and sheds light on how knowledge is constructed from a particular racial and social perspective, broadening the knowledge base by including voices from culturally diverse groups. The second dimension, knowledge construction, aims to reveal to students how subject matter is shaped by various racial and social perspectives, moving away from a privileged Eurocentric, Americanized knowledge base. It also seeks to reduce prejudicial discrimination by creating opportunities for students to develop more democratic attitudes and behavior.

The third aspect, equity pedagogy, emphasizes the importance of culturally responsive educators who strive to provide equal learning opportunities and employ strategies to support academically challenged students from diverse cultural backgrounds (Banks, 2001). The fourth aspect is prejudice reduction, which promotes mutual understanding and acceptance among students from diverse cultural backgrounds to reduce stereotypes and prejudices.

The fifth dimension, empowering social culture and social structure, calls upon culturally responsive teachers to support efforts to restructure schools both organizationally and culturally (Banks, 2001). This restructuring seeks to advance educational equity and foster cultural affirmation for all students. This model encourages teachers to shift from traditional teaching methods to transformative teaching and social activism. A culturally responsive curriculum allows students to examine issues from diverse perspectives. Furthermore, it encourages students to analyze these issues critically, engaging in genuine problem-solving and discussions related to

social justice. It is worth noting that this model is not limited to K–12 students; it is equally crucial to incorporate it into teacher preparation programs. Educators can gain knowledge and skills to develop multicultural curricula (Deborah, 2012).

Aronson and Laughter (2016) suggested that two distinct primary stances emerged, separate from the field of multicultural education. One stance focused on teacher practices, exemplified in Gay's works (1980, 2002, 2013, 2018) and CRT. The other stance centered around teachers' posture and paradigm, as articulated by Ladson-Billings (1994, 1995a, 1995b, 2006, 2014), and culturally relevant pedagogy. Although the terms are often used interchangeably, Aronson and Laughter (2016) distinguish these two stances to address distinct but complementary outcomes: teaching effects, competency, and practice on the one hand and attitude and disposition influenced by pedagogy on the other. Furthermore, they emphasized that both frameworks share a joint commitment to social justice, education, and the transformative potential of classrooms as catalysts for social change.

Subsequently, Gay (2000) built upon Ladson-Billings' (1995) idea in her work. Gay (2000) described CRT as leveraging cultural knowledge and prior experiences to assist ethnically diverse students in creating relevant and effective learning experiences. This approach invites students to bring their experiences, thought processes, and learning traits into the classroom. The following section provides a comprehensive overview of Gay's work.

Many researchers and practitioners have expanded on Ladson-Billings and Gays' fundamental ideas. Their work has been pivotal in helping educators and researchers grasp the importance of cultural relevancy in teaching, influencing decisions regarding curriculum and instructional approaches, and creating inclusive classroom environments. In addition to these scholars, CRT has drawn inspiration from critical theories such as critical race theory and critical

pedagogy, emphasizing the examination of power dynamics, privilege, and social justice issues within educational settings. CRT continues to evolve, reflecting ongoing efforts to address the complex challenges of creating inclusive and equitable environments (Banks, 2001). Its origins in the civil rights movement and the contribution of scholars like Ladson-Billings, Banks, and Gay have laid the foundations for pedagogical approaches that seek to empower students of all backgrounds and promote social justice in education.

The current research focuses on CRT rooted in the principles highlighted by Gay (2002) within the larger multicultural education framework. Gay (2000) underscores the importance of integrating students' diverse cultural perspectives and experiences into instruction to support their academic success. Similarly, Banks (2001) highlights that multicultural education promotes equity by encouraging inclusive practices that value and respect cultural diversity. Taken together, the principles outlined by Gay (2002) and Banks (2001) suggest that CRT and multicultural education share a commitment to inclusive pedagogy that not only affirms cultural identity but also promotes academic success. This aligns with the purpose of the current study: to examine how Culturally Responsive Mathematics Teaching (CRMT) influences the engagement of culturally diverse learners (CDLs) in a high school geometry class and to explore ways of making mathematical learning more meaningful and engaging for these students.

**Culturally Responsive Teaching Practices - Geneva Gay's Pedagogy**

Gay (2000) pioneered CRT as "using cultural characters, experiences, and perspectives of ethnically diverse students as channels for teaching students more effectively" (p. 106). She defined CRT "as using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to

and effective for them" (p. 31). CRT is designed to help create a classroom environment where students from diverse cultural backgrounds feel included.

CRT aims to use students' unique characteristics and experiences to enhance learning processes. The six key aspects of this approach, explaining how to implement CRT, outlined by Gay (2000), are as follows:

- CRT aims to help students succeed in their studies and develop into capable members of society. Gay (2000) wrote, "Empowerment translates to academic competence, personal confidence, courage, and the will to act" (p. 32). Teachers following this approach have higher standards for all students and their accomplishments. This practice empowers students academically and enhances their skills, self-assurance, and determination to take initiative. In doing so, students find their place within the learning process and cultivate a positive belief in their capabilities to grasp concepts. Gay (2000) added that it is essential for teachers to keep high expectations while empathizing with the challenges students face.
- CRT is multidimensional. Gay (2000) wrote, "Emotions, beliefs, values, ethnos, opinions, and feelings are scrutinized along with factual information to make curriculum and instruction more reflective of and responsive to ethnic groups" (pp. 31–32). She further explained that culturally responsive educators possess multiple dimensions as they engage with cultural knowledge, experiences, contributions, and viewpoints. This multidimensional approach encompasses the curriculum, learning environment, student-teacher relationships, interactions, instructional strategies, and assessment. This method challenges students to comprehend the concept across various fields critically. Such teaching requires educators to possess extensive cultural knowledge, contributions, and perspectives. This type of teaching concentrates on cultural socialization that directly influences the learning process.

- CRT validates students by closing gaps between students, schools, and homes using diverse teaching methods and a multicultural curriculum (Gay, 2000). Teachers who genuinely validate students possess specific characteristics, such as recognizing the significance of integrating students' cultural backgrounds into the curriculum and connecting their home and school experiences. They also employ various teaching strategies to cater to different learning styles. This approach fosters a positive self-identity and an appreciation for human differences. The practice of validation within the learning environment can benefit all students, including those from diverse cultural backgrounds.
- CRT is comprehensive as it focuses on the students' holistic development (Gay, 2000). Beyond fostering academic achievement, this approach helps students preserve their ethnic identities and nurture feelings of unity, togetherness, and collective accountability. The educational process is a communal, mutually beneficial, and interconnected experience.
- CRT is transformative by establishing academic success as an essential requirement and an attainable objective for every student (Gay, 2000). This approach not only advocates for this principle but also cultivates the abilities needed to put it into action, emphasizing that students are responsible for contributing positively to their communities and the broader national society. It encourages students to tackle societal challenges by harnessing their existing knowledge, thereby sparking their motivation to find solutions. By utilizing students' inherent strengths, CRT can bring changes to educational institutions and society at large. It transforms teaching methods, evaluations, and curricular planning to align with students' strengths and potential.
- CRT is emancipatory because it empowers students from diverse backgrounds to reclaim their cultural identities, challenge oppressive norms, and actively engage in learning (Gay, 2000). Incorporating students' cultural perspectives, experiences, and strengths breaks down barriers

and enables them to take control of their education, fostering a sense of liberation and self-determination. This approach serves as a vehicle for students to critically analyze their world critically, promoting social justice and transformative changes in their educational landscape.

Gay (2013) noted that it is essential first to explore the five key elements of culturally responsive instructional practices. These CRT practices include "developing a knowledge base about cultural diversity, including ethnic and cultural diversity content into the curriculum, demonstrating caring and building learning communities, communicating with ethnically diverse students and families, and responding to ethnic diversity in the delivery of instruction" (p. 106). While Gay emphasized the importance of cultural relevance in every aspect of teaching, she acknowledged the potential constraints of CRT implementation.

- ***Developing a Diversity Knowledge Base.*** To effectively serve students in our current educational system, educators need to understand different cultural groups well. This knowledge helps educators develop awareness of diverse cultural groups to effectively teach CDLs (Delpit, 2006; Gay, 2002; Villegas & Lucas, 2002). It is more than simply knowing the culture; it is also about understanding students' backgrounds. When teachers do this, they can adapt their teaching methods to suit the students' cultural needs. Additionally, understanding students' cultural backgrounds can enhance instructional practices, leading to more meaningful and effective learning experiences for CDLs (Villegas & Lucas, 2002). Thus, by connecting with students from diverse backgrounds, teachers can create inclusive and fair classrooms where students' identities matter in the learning process.
- ***Including Ethnically and Culturally Diverse Content.*** *For the second component,* Gay (2002) suggested educators implement cultural diversity into their content. Tailoring content for diverse students is an appropriate, unbiased approach. In addition, tailored content makes learning

conducive to CDL, thus improving comprehension and academic success (Gay, 2002; Ladson-Billings, 1995; Villegas & Lucas, 2002).

- ***Demonstrating Care and Building Learning Communities.*** CRT places "teachers in an ethically, emotional, and academic partnership with ethnically diverse students, a partnership that is anchored in respect, honor, integrity, resource sharing, and deep beliefs in the possibility of transcendence" (Gay, 2002, p. 109). This is a critical component of CRT that fosters action-oriented educators who have high expectations for student academic success. Gay proposed that educators genuinely believe that all students can be academically successful, and teachers must provide culturally appropriate learning opportunities.
- ***Establishing Cross-Cultural Communication.*** Gay (2002) wrote about the cross-cultural communication component from multiple angles. Communication includes students and their families. She reiterates the importance of educators' cultural knowledge that incorporates students' families. She also reported that educators must be aware of different communication styles to encourage classroom discussions.

Researchers have proposed that CRT can provide instructional support that enhances students' learning by utilizing their experiences and knowledge (Gay, 2000; Hammond, 2015; Ladson-Billings, 1997). Researchers consistently emphasize that teachers need a deeper understanding of their students' worlds for better learning outcomes (Delpit, 2006; Gay, 2000; Hammond, 2015; Ladson-Billings, 1997; Nieto, 2002). Moreover, researchers suggest that increased cultural self-awareness in teachers enables them to tailor teaching strategies to their students' diverse cultural needs by bridging the gap between home and school cultures (Bankston & Zhou, 2002; Gay, 2000; Nieto, 2002). The importance of educators understanding

students' cultural and social contexts, which traditional settings often overlook, is emphasized in current research.

**Culturally Responsive Mathematics Teaching**

Traditional mathematics instruction often overlooks students' diverse cultural backgrounds and experiences, a limitation that Culturally Responsive Mathematics Teaching (CRMT) directly addresses (Greer et al., 2009). As a response to these educational disparities, CRMT promotes a more inclusive and accessible mathematics learning experience. It emphasizes the importance of acknowledging and valuing students' cultural diversity to ensure mathematics instruction is both equitable and relevant to all learners (Ladson-Billings, 1997). In doing so, CRMT strives to bridge gaps in educational access and opportunity, advancing a more effective and meaningful mathematics education for culturally diverse students.

Mathematics, like other human activities, is shaped by historical, cultural, social, and political influences (Greer et al., 2009). Gay (2000) emphasized that Culturally Responsive Teaching (CRT) is highly applicable to mathematics education and highlighted the importance of educators developing strong cultural competence. CRMT builds on this perspective by promoting equity and enhancing students' conceptual understanding through culturally inclusive strategies. It challenges the notion that mathematics is culturally neutral, instead asserting that students from diverse backgrounds can thrive when their cultural identities are validated and connected to learning (Greer et al., 2009).

The CRMT framework is grounded in enhancing the mathematical proficiency of culturally diverse learners (CDLs) and promoting diverse ways of thinking to support deeper understanding (Bonner, 2021). While CRMT is not a fixed set of practices, research has identified common cornerstones such as affirming cultural identity, promoting instructional

engagement, holding high expectations, encouraging critical thinking, supporting teacher reflection, fostering collaboration, and addressing social justice issues (Abdulrahim & Orosco, 2020; Bonner, 2021; Bonner & Adams, 2012; Gay, 2018; Hammond, 2015). These elements demonstrate strong alignment with both culturally responsive and culturally relevant pedagogies, emphasizing the importance of tailoring instruction to meet the needs of CDLs.

By centering students' mathematical reasoning and cultural identities, CRMT fosters a classroom environment that moves beyond traditional, one-size-fits-all approaches. It creates a space where students' unique methods of reasoning are valued as essential contributions to the collective learning process. In such classrooms, students not only feel seen and respected but also gain confidence in their mathematical abilities (Aguirre & Zavala, 2013; Ladson-Billings, 1995a, 2009, 2014). In addition to the cultural identities and experiences they bring, students also bring culturally shaped approaches to mathematical reasoning and problem solving, which influence how they make sense of tasks and engage with instruction. This perspective encourages students to engage in mathematics from their cultural viewpoints, ultimately enriching classroom discourse and enhancing engagement.

Abdulrahim and Orosco (2020) conducted a comprehensive synthesis of 35 CRMT studies conducted between 1993 and 2018. Their findings confirmed that, although CRMT does not consist of a standardized set of practices, most studies emphasized similar principles such as cultural identity, instructional engagement, high expectations, critical thinking, teacher reflection, collaboration, and social justice (Abdulrahim & Orosco, 2020; Bonner, 2021; Bonner & Adams, 2011; Gay, 2018; Hammond, 2015).

Over the past decade, mathematics education research has increasingly focused on identifying evidence-based practices that develop students' foundational and problem-solving

skills (Rittle-Johnson & Jordan, 2016). While many of these efforts have aimed to raise mathematics proficiency among CDLs, they have often overlooked the broader educational context. Factors such as classroom expectations, rigor of coursework, teacher–student relationships, and parental involvement all significantly influence students' learning experiences and trajectories (Berry, 2008; Gutiérrez & Dixon-Román, 2011; Stinson, 2007). CRMT provides an equity-centered instructional framework that contextualizes learning within these larger dynamics, offering educators tools to create meaningful and inclusive mathematical experiences (Abdulrahim & Orosco, 2020; Celedón-Pattichis et al., 2018).

Rather than focusing on quantifiable outcomes, this research prioritizes students' development of mathematical skills as tools for future opportunities and careers. However, Bonner (2009) noted that educators often struggle to apply CRMT effectively in mathematics classrooms, particularly in contexts not explicitly designed to support culturally responsive instruction (Aguirre & del Rosario Zavala, 2013; Bonner, 2009). Dornoo (2015) expanded on the CRMT framework by outlining instructional strategies that help educators teach mathematical concepts in ways that are inclusive of students' cultural identities. Similarly, Goldenberg (2014) highlighted the importance of using real-world problems to make math instruction more meaningful for CDLs, stating, "Besides science, mathematics, as well as often being the most challenging topic for teachers to embrace, students' cultural capital is, because, on the surface, there are no ways for students' culture to relate to the curriculum or teachers' lesson plans" (p. 20).

Aligned with Goldenberg's observation, this study investigates how CRMT can support student engagement in a high school geometry class by making instruction more meaningful and culturally relevant for culturally diverse learners (CDLs). Specifically, the study examines how

teachers can utilize CRMT strategies to validate students' identities, incorporate real-world contexts, and promote inclusive mathematical discussions. By doing so, it aims to highlight practical ways to bridge cultural connections in mathematics and promote deeper engagement among students who traditional instructional models often underserve.

**Culturally Responsive Mathematics Teaching Effectiveness**

Recent advancements in mathematics education underscore the growing importance of cultural responsiveness, particularly in developing instructional strategies that cater to the diverse needs of learners. Several researchers have contributed to CRMT-related scholarship in the field, as summarized in Table 1. Lipka et al. (2005) explored how mathematical instruction rooted in students' cultural contexts enhanced learning among Yupiaq elementary students. Their study of the Mathematics in Cultural Context (MCC) project involved four Yupiaq teachers and community adults demonstrating cultural practices such as building a kayak, sewing border patterns, and navigating with the stars. One kindergarten teacher taught geometry through border designs, and pre- and post-assessments showed significant gains in geometric understanding. Pre- and post-assessments indicated significant gains in students' understanding of geometric concepts.

Moses-Snipes (2005) conducted a quasi-experimental study with African American fifth graders, comparing two groups: one using Mathematics With Culture (MWC) and another using Mathematics Without Culture (MWOC). Students in the MWC group demonstrated substantial gains in post-assessments, highlighting the academic benefits of embedding cultural context into mathematics instruction.

A large-scale example of CRMT implementation is The Algebra Project, developed by Bob Moses and operating across 12 states. The program raised mathematics literacy among

students in the lowest quartile to national achievement levels (Gay, 2002; Moses & Cobb, 2001). Importantly, it emphasized sociocultural relevance by integrating students' lived experiences and community knowledge into instruction.

These studies demonstrate how CRMT can enhance mathematics outcomes while promoting inclusive and affirming classroom environments. Notably, they underscore CRMT's potential to bridge opportunity gaps for culturally diverse learners (CDLs), particularly in secondary classrooms, making this study both timely and relevant.

Beyond academic achievement, literature emphasizes the broader benefits of CRMT, such as cultural affirmation, engagement, and equitable participation. These outcomes support a more comprehensive educational approach for meeting the needs of secondary-level CDLs. To extend the success seen in initiatives like The Algebra Project into today's diverse classroom contexts, it is essential to explore adaptable instructional frameworks, which are discussed in the following section.

To guide implementation, Bonner and Adams (2012) proposed a CRMT framework with four foundational elements:

1. Knowledge, which includes students' cultural backgrounds.
2. Communication, which assesses educators' communicative skills and abilities to link mathematics content with students' culture.
3. Relationship building between educators, CDLs, and their families.
4. Reflection and revision, which encourages educators to accommodate student insights.

These elements are echoed in other studies that use CRP and CRT to support CDL learning.

Gutiérrez (2000) examined how Latino/a and African American students advanced to higher-level mathematics using an interdisciplinary CRP framework. Her study focused on eight

mathematics departments in an urban school, which successfully supported the progression of African American students in mathematics.

Jett (2013) implemented CRT strategies in his mathematics teaching by seeking prior knowledge of his African American students' cultures, interests, and backgrounds. He encouraged his college students to think critically and collaboratively from different perspectives. Cholewa et al. (2012) explored the relationship between CRMT teachers and culturally and linguistically diverse (CLD) students using the CRT framework grounded in CRP and CRT to connect with CDLs and make mathematics teaching more meaningful to students. They found improvement in students' engagement.

Recent studies further expand the evidence base for CRMT. For example, Harris et al. (2023) identified nine culturally responsive practices for mathematics instruction and examined how existing elementary and secondary math curricula fall short in addressing cultural diversity. Their work emphasizes the structural gaps in current curricular materials and offers practical guidance for curriculum developers. In a comprehensive research synthesis, Mamedova and Orosco (2024) analyzed fifteen classroom-based CRMT studies and identified instructional practices that most effectively support engagement among students. Their findings underscore the importance of tailoring instruction to cultural contexts to enhance classroom participation and mathematical understanding. Additionally, Redding (2024) studied secondary math teachers in southwest Virginia who participated in professional development focused on CRMT. The study found that collaborative and reflective practices significantly improved teacher self-efficacy in implementing culturally responsive strategies. These recent contributions further affirm the relevance and urgency of adopting CRMT in diverse secondary math classrooms.

Table 1

*Researchers and Studies on Culturally Responsive Mathematics Teaching*

| **Study** | **Participants** | **Main Findings** |
|---|---|---|
| Gutiérrez (2000) | Latino/a and African American high school students | An interdisciplinary framework using CRP helped students advance to higher-level mathematics courses |
| Lipka et al. (2005) | Sixth-grade American Indian/Native Alaskan students | Culturally relevant mathematics instruction improved students' mathematics outcomes |
| Moses-Snipes (2005) | African American fifth graders | A quasi-experimental study found that incorporating Mathematics With Culture (MWC) improved achievement in comparison to Mathematics Without Culture (MWOC). |
| Ukpokodu (2011) | Middle school students Explored CRP implementation in, incorporating students' cultural heritage into the classroom | Fostering mathematical literacy among diverse students is crucial for promoting critical citizenship. Educators must adopt culturally responsive practices to promote mobility. |
| Boaler (2008); Boaler and Adams (2012) | 700 high school students from three urban high schools | CRP-based mathematics instruction improved students' mathematics outcomes |
| Bonner and Adams (2012) | Low-income African American fifth-grade students | Improved mathematics learning outcomes for low-income African American students with CRMT |
| Cholewa et al. (2012) | CRMT teachers and CDL students | Culturally responsive teaching grounded in CRP and CRT improved students' engagement. |
| Aguirre and del Rosario Zavala (2013) | Students from culturally diverse backgrounds A framework of community knowledge in which students, families, and community members participate in social justice mathematics activities | The pedagogical tool they created enables teachers to critically analyze math lessons and engage in meaningful dialogue, improving teaching quality and cultural responsiveness. |

| | | |
|---|---|---|
| Jett (2013) | African American college students | CRT strategies integrated in mathematics teaching encouraged critical thinking and collaboration |
| Aguirre and Zavala (2013) | Six White females and one White male teacher in elementary and middle schools | CRMT practices benefited students from diverse backgrounds |
| Bonner (2014) | Teachers from White, African American, and Mexican Arab communities | CRMT practices made mathematics teaching more meaningful to students |
| Warrens (2018) | Pre-service teachers | CRP-based strategies that incorporate empathy and student perspective improve teaching practices. |
| Harris et al. (2023) | Elementary & secondary curriculum developers | Outlines 9 CRMT practices and highlights limitations in current math curricula |
| Mamedova & Orosco (2024) | 15 classroom-based CRMT studies | Identifies key instructional elements supporting CLD engagement |
| Redding (2024) | Secondary math teachers (SW Virginia PD) | PD improved teacher self-efficacy in CRMT through collaborative and reflective practices. |

The studies in Table 1 aimed to enhance students' mathematical understanding by integrating the cultural backgrounds of culturally diverse learners (CDLs) into instruction and fostering cultural awareness. While findings consistently affirm the positive impact of CRMT strategies, further comprehensive research is needed, particularly at the high school level, to understand their broader effectiveness. This gap highlights the importance of the present study's focus on secondary mathematics classrooms.

**Researched CRMT Practices**

Incorporating cultural references through CRT positively influences students' intellectual, social, and emotional development (Milner, 2013). Integrating cultural identity into instruction enhances students' focus and engagement (Gay, 2002). Milner further advocates for CRT as a

tool to strengthen relationships among teachers, students, families, and communities, an essential foundation for academic success.

***Cultural Identity.*** Educators who integrate students' cultural backgrounds into mathematics instruction help shape both their cultural and mathematical identities. Abdulrahim and Orosco (2020) describe cultural identity as an evolving sense of self that is shaped by both dominant and community cultures. For example, Clark et al. (2013) examined two high school teachers who connected domain and range functions to students' neighborhoods and home states. Similarly, another study linked the concept of factoring numbers to family roles and dynamics valued in African American culture (Abdulrahim & Orosco, 2020).

Gutiérrez (2000) assessed teachers who encouraged peer interaction of their Latino/a students who practiced higher-level mathematics (e.g., reasoning, problem-solving) using their native Spanish and English languages. During learning activities, students (i.e., English speakers) used both English and Spanish to discuss mathematics, promoting bilingualism as a valuable resource for mathematics. As a result, the students' sociocultural knowledge was a valuable mathematical resource, allowing them to make meaningful connections with mathematics.

***Instructional Engagement.*** Instructional engagement signifies active engagement and interaction with the learning environment. Hammond (2015) explained that culturally responsive teachers nurture strong student engagement and support by creating learning environments receptive to CDLs' social, emotional, and cognitive needs. In prior work, teachers have connected students' home experiences to mathematical problem-solving to demonstrate ways to improve students' lives and the lives of others (Hubert, 2014; Tate, 1995). In Gutstein's (2003) study, students expressed positive attitudes toward mathematics and viewed it as valuable for understanding the world. Abdulrahim and Oroscos' (2020) synthesis revealed that CRMT

implementation strategies promoted group discussions on human experiences, drew meaningful connections from cultural activities, and used mathematics learning platforms to address social justice issues.

***Higher Expectations.*** CDLs are more likely to succeed in mathematics when their teachers believe in their abilities (Gay, 2002). For example, the teacher in Tate's (1995) study designed a three-step implementation plan to support student participation in resolving community-based issues, thus maintaining high expectations for her CDLs. Similarly, Gutiérrez (2000) found that teachers who held high expectations not only communicated them clearly but also provided academic support through tutorials, thereby reinforcing the belief that all students could succeed.

***Students' Critical Thinking.*** CDLs' critical thinking skills contribute to academic and professional success (Abdulrahim & Orosco, 2020). CRMT practices that utilize multiple problem-solving strategies prepare CDLs as resourceful problem solvers. In published work, CDLs reported improved critical thinking skills when teachers expected CDL to use multiple problem-solving strategies (Bonner, 2014; Bonner & Adams, 2012; Cholewa et al., 2012; Gutiérrez, 2000). Hence, preparing CDLs with problem-solving and critical thinking skills can help them achieve academic and professional success.

Previous studies have demonstrated that implementing CRMT practices, which connect mathematics content to students' cultural identities, consistently leads to higher expectations and improved instructional engagement and critical thinking skills among CDLs (Boaler, 2008; Gutstein et al., 1997; Ladson-Billings, 1997). While many of these findings do not exclusively target secondary mathematics classrooms, they provide critical guidance for this study. The documented benefits of CRMT/CRT, in shaping identity, fostering engagement, and enhancing

critical thinking, have directly informed the practices explored in my research on culturally diverse learners in high school geometry.

**Culturally Responsive Mathematics Teaching: Teacher Practices**

Addressing the cultural and linguistic diversity of students in mathematics classrooms is central to effectively implementing CRMT strategies. Teachers may need to develop new skills and deepen their pedagogical awareness to ensure that instructional methods are inclusive and equitable. Culturally diverse learners (CDLs) enter math classrooms with a range of experiences shaped by their language, culture, and community. Their academic success often depends on creating inclusive learning environments that affirm their identities (Gutiérrez, 2000). Furthermore, effective teacher communication and genuine care are critical for cultivating interactive classroom spaces where students feel supported (Abdulrahim & Orosco, 2020).

Teachers who adopt culturally responsive teaching (CRT) must critically examine both the diversity of their students and their own beliefs, values, and assumptions about race, ethnicity, and culture (Gutstein, 2003). Foundational frameworks from Ladson-Billings (1997) and Gay (2002) emphasize the need for instructional practices that validate the cultural experiences of CDLs. These frameworks argue that teachers play a vital role in fostering classroom connections that affirm students' cultural identities and promote academic growth. As teacher collaborations have evolved, efforts to champion diversity, build partnerships, share instructional resources, and promote deeper understanding of mathematical content have become more intentional (Abdulrahim & Orosco, 2020). The following subsections outline three key practices, collaboration and social justice, that support teachers in implementing CRMT effectively.

***Educators' Reflection.*** A cornerstone of CRMT implementation is educators' ongoing self-reflection about their own cultural biases, values, and racial perspectives (Gay, 2013). This reflective process is essential for delivering culturally competent mathematics instruction. Research has shown that reflective teaching enables educators to design instructions that meaningfully connect students' lived experiences to mathematical content (Bonner & Adams, 2012; Gutstein et al., 1997). For instance, Bonner (2014) documented how three mathematics teachers created classroom environments that reflected their students' realities. By aligning instruction with students' daily lives, they improved engagement and comprehension. These findings emphasize that teacher reflection fosters more authentic connections to student experiences, supporting deeper mathematical understanding among CDLs (Abdulrahim & Orosco, 2020).

***Collaboration.*** Collaboration among students and between educators is another critical component of CRMT. When teachers facilitate student collaboration, CDLs are more likely to engage and succeed (Boaler, 2008; Cholewa et al., 2012; Gutiérrez, 2000). Hubert (2014) found that assigning proficient students to assist their peers improved understanding of complex topics such as quadratic and exponential functions. This group-based approach enhanced both participation and comprehension among CDLs. Additionally, Gutiérrez (2000) advocated for teacher collaboration to ensure that students are well prepared for advanced mathematics in high school. These examples demonstrate how collaborative practices enhance instructional support for CDLs and foster equitable learning outcomes.

***Social Justice.*** Social justice is also a foundational pillar of CRMT. As emphasized by Ladson-Billings (1995), incorporating social justice into mathematics education helps CDLs critique systemic inequalities related to educational opportunities, resources, and achievement.

Tate (1995) demonstrated that teachers can use mathematics to empower students to examine real-world issues, including power dynamics and social disparities. Similarly, Gutiérrez (2000) showed how mathematics instruction can be leveraged to develop students' critical consciousness about oppression, inequity, and poverty. Teaching mathematics through a social justice lens not only enhances students' problem-solving skills but also prepares them to be informed and active citizens.

Together, these research findings highlight the transformative power of educator reflection, intentional collaboration, and social justice-oriented instruction in supporting culturally diverse learners. These interconnected practices not only enhance mathematics instruction but also build inclusive learning communities. By adopting these strategies, teachers can contribute to a more equitable educational experience for all students, especially those from culturally and linguistically diverse backgrounds.

**Teachers' Challenges: Training and Resources**

Supporting culturally diverse learners (CDLs) in mathematics education presents several challenges that have been well documented in the research literature. Ladson-Billings (1997) highlighted the urgent need for improved teacher preparation and a stronger emphasis on integrating culturally relevant content into mathematics lesson planning. She also pointed to the limited availability of appropriate resources for culturally responsive mathematics instruction and the widespread misconception that mathematics is culturally neutral and color-blind, an assumption that hinders the inclusion of diverse perspectives. Similarly, Milner (2013) noted that mathematics is often treated as fundamentally different from other subject areas, leading to a lack of attention to cultural inclusion. This disconnect leaves many teachers unprepared to meet the needs of CDLs in their classrooms. In addition, Gay (2000), Howard (2003), Banks (2016), and

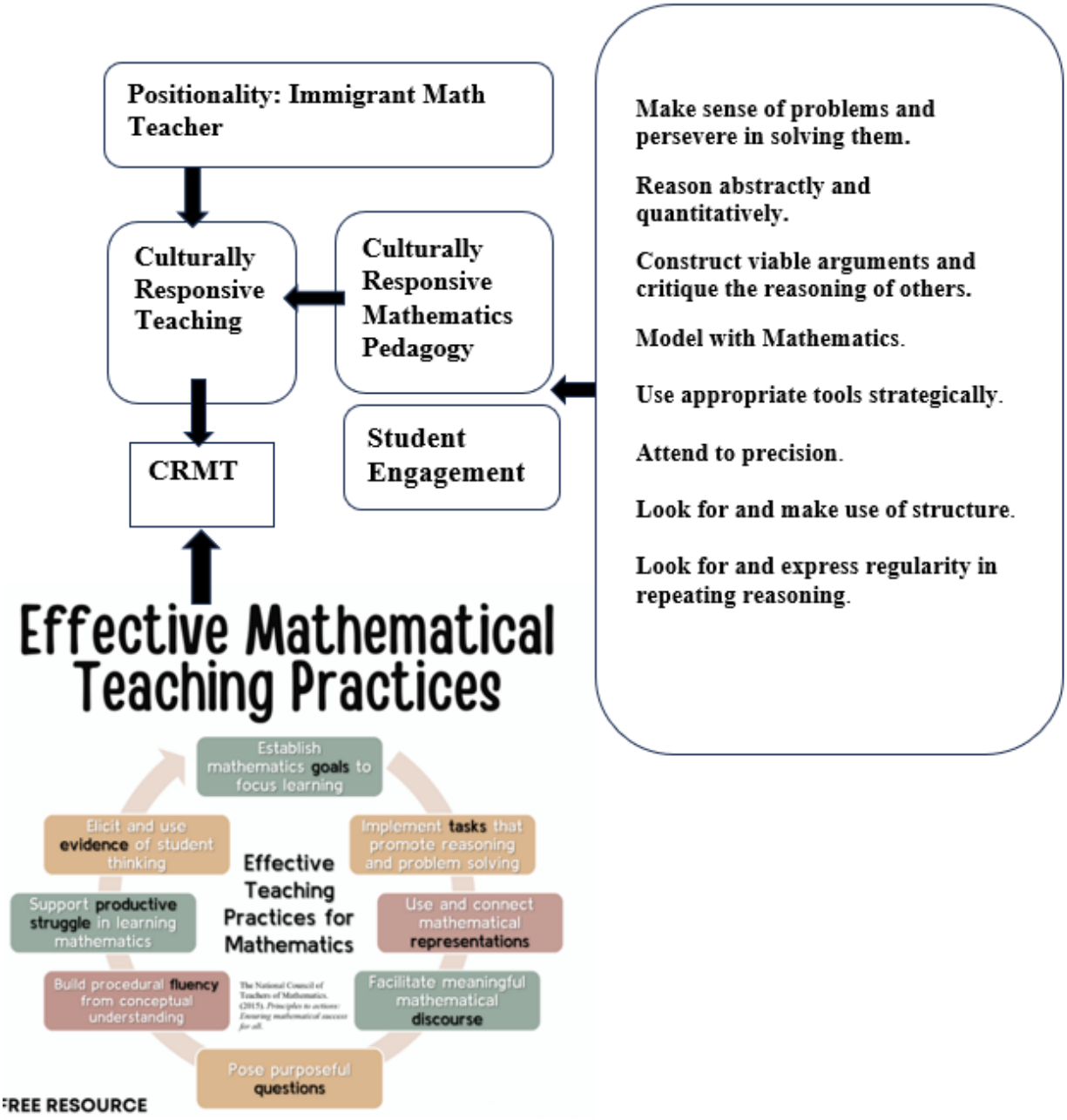
Özüdoğru (2018) have explored the complexities of implementing CRT in practice, underscoring the systemic barriers educators face. Collectively, these challenges emphasize the need for comprehensive and sustained support for teachers. One way to address these challenges is through the use of a clear and grounded conceptual framework.

**Conceptual Framework**

Adjusting traditional mathematics classrooms to better support students with diverse cultural and academic needs is essential. To address this, I developed a conceptual framework grounded in my dual role as both a mathematics educator and an immigrant, informed by the literature on CRT. As shown in Figure 1, this framework is centered on CRMT as the primary lens through which student engagement is examined. CRMT, in this context, is operationalized through the integration of Geneva Gay's (2002, 2010, 2013) CRT practices, the SMPs, and the NCTM Effective Mathematics Teaching Practices (2014). These interconnected components collectively support a teaching approach that affirms students' cultural identities, fosters mathematical understanding, and promotes meaningful engagement for culturally diverse learners (CDLs).

***Figure 1.***

*Conceptual Map*




*Note*. Adapted from the study design by the researcher.

The CRMT framework enhances student engagement by offering effective, research-based instructional strategies, serving as the foundation of this study. Grounded in Geneva Gay's (2002, 2010, 2013) CRT principles, this framework centers on practices that affirm students' cultural identities, build meaningful relationships, and maintain high expectations for academic success. These principles provide a foundation for fostering inclusive, student-centered learning environments that resonate with CDLs.

As an immigrant mathematics teacher, my unique perspective informs and enriches this conceptual framework. My lived experiences shape my understanding of the classroom as a space where students' cultural knowledge should be validated and leveraged to enhance engagement and mathematical understanding. This research focuses on how CRT-based practices in a geometry classroom support student engagement among CDLs by making instruction more relevant, relational, and responsive.

This framework aligns with the study's core components. The first section centers on designing lessons that reflect CRMT principles, integrating culturally responsive strategies to enhance students' sense of belonging and participation. These instructional practices promote a shift from traditional teacher-centered methods toward student-centered learning, drawing on the framework proposed by Hufferd-Ackles et al. (2004). Their model highlights four dimensions critical to fostering student engagement: teacher questioning, student explanation and justification of thinking, student discovery, and ownership of mathematical ideas.

In the concluding section, the study evaluates student engagement using the SMPs (NGA & CCSSO, 2010) as a lens. The SMPs provide a concrete and observable framework for assessing the depth and nature of student participation in mathematical tasks. These practices,

such as making sense of problems, reasoning abstractly, constructing arguments, and modeling with mathematics, serve as indicators of engaged and meaningful learning within a culturally responsive instructional context. Together with CRT principles, the SMPs offer a structured yet flexible approach to analyzing how CRMT fosters engagement among culturally diverse learners.

# CHAPTER 3 METHODOLOGY

The primary objective of this research was to investigate CRMT instructional practices on student engagement in a high school geometry class, with a particular attention to CDLs. The study employed the CRMT framework, as outlined in the literature review, emphasizing student-centered instruction, high academic expectations, cultural relevance, and real-world connections. The SMPs were integrated as an analytic lens to examine how CRMT-aligned instruction supported students' engagement and mathematical reasoning. Drawing on this conceptual framework and utilizing student interviews, lesson reflections, and classroom observations, the study aimed to provide in-depth insights into how CRMT impacted student engagement in secondary mathematics education.

The primary goal of this chapter is to describe the approach, design, and procedures used to investigate research questions. This chapter outlines the methodological approach, research design, data collection, analysis, and ethical considerations that guided the study. It establishes credibility, explains how the research was conducted, and addresses potential limitations transparently. This study aimed to answer the following research questions:

1. How did integrating Culturally Responsive Mathematics Teaching (CRMT) in a high school geometry class impact student engagement during instruction and in-class activities that promoted the Standards for Mathematical Practice (SMPs)?
2. How did students describe the impact of CRMT-based instruction on their engagement and learning in a geometry class?

These research questions guided the methodological choices described in this chapter and framed the analysis presented in Chapter 4.

## Qualitative Research

This study employed a qualitative case study design to provide a rich, contextualized understanding of human experiences, actions, and interactions (Creswell, 2013). Rather than testing hypotheses, qualitative research uses an inductive approach, allowing themes and patterns to emerge from data collected in natural settings. Such methods capture the complexity of participants' lived experiences, particularly when exploring social and cultural phenomena such as teaching and learning.

Marshall et al. (2022) describe qualitative research as "pragmatic, interpretive, and grounded in the lived experience, experiences of people" (p. 2). This study was grounded in the interpretive paradigm, which posits that reality is socially constructed and best understood through the subjective experiences of individuals (Denzin & Lincoln, 2003). From this perspective, educational practices such as CRMT are shaped by learners' cultural identities, beliefs, and interactions. Thus, the study acknowledges that there is no single objective truth, but rather multiple perspectives shaped by cultural and personal contexts (Creswell, 2013; Guba & Lincoln, 2005).

By centering students' voices and cultural perspectives, this interpretive approach enabled deeper exploration of how CDLs perceive and engage with CRMT practices. Through student interviews, classroom observations, and reflections, the study sought to understand how CRMT strategies influenced engagement in ways that were meaningful to students themselves. Consistent with Fredricks et al.'s (2004) tripartite framework, engagement was considered across behavioral, emotional, and cognitive dimensions, which were examined qualitatively in classroom contexts.

Qualitative research is particularly well-suited for studies of CRMT because it attends to tacit knowledge, cultural nuance, and subjectivity (Marshall et al., 2022). Tacit knowledge refers to the unspoken, culturally grounded understandings that CDLs bring into the classroom, while subjectivity reflects how students interpret, experience, and respond to instruction. These dimensions are crucial for interpreting how engagement emerges through CRMT strategies in real-world settings.

This approach incorporated multiple data sources, interviews, reflections, and artifacts to construct a holistic view of student engagement. It recognizes that human actions in educational settings are shaped by thoughts, feelings, values, and assumptions (Stake, 1995; Strauss & Corbin, 1998). Thus, this study used qualitative methods to explore the cultural, emotional, and participatory dimensions of engagement that cannot be captured through quantitative instruments.

Finally, the case study approach aligned directly with the research questions, which sought to explore student engagement and perceptions of CRMT in a high school geometry class. Rather than relying on numerical indicators, the study drew descriptive data from student interviews, lesson reflections, and classroom artifacts to capture how engagement manifested in response to CRMT-aligned instruction. The interpretive nature of qualitative inquiry enabled coding and thematic analysis that revealed patterns of participation, interest, and confidence, as expressed by students themselves. This ensured that the findings reflected the lived experiences of CDLs and aligned with the culturally responsive goals of the study.

**Case Study**

This study employed a qualitative case study design to investigate how CRMT strategies influenced student engagement in a high school geometry class. A case study involves an in-

depth exploration of a bounded system, such as a classroom, event, or group, to gain a holistic understanding of a phenomenon within its real-life context (Merriam, 1998; Stake, 1995; Yin, 2002). According to Stake (1995), researchers construct meaning through both direct interpretation of individual instances and the aggregation of multiple data points. Case studies enable researchers to capture rich, contextualized insights and construct themes through layered and iterative analysis (Merriam, 1998; Stake, 1995; Yin, 2002).

Hays and Singh (2012) emphasize that case studies allow researchers to examine complex educational issues and processes through careful case selection, multiple data sources, and a deep analysis of participants' lived experiences. Creswell (2013) notes that case studies require the researcher's active participation and reflect a constructivist orientation, one that values multiple realities and subjective interpretation.

This study drew on the educational case study traditions of Merriam (1998), Stake (1995), and Yin (2002), as clarified by Yazan (2015). Aligned with the interpretive paradigm, the case study enabled an in-depth examination of how CRMT practices influenced engagement among culturally diverse learners (CDLs). The design also reflected my positionality as a teacher-researcher, with reflexive notes and strategies to monitor bias, embedded within the case. As the primary instrument of data collection and analysis, I conducted the study in my own classroom, enabling a naturalistic and context-rich exploration of how CRMT was enacted and experienced.

The decision to use a case study approach was further informed by the opportunity to collect data in a natural school setting, where CRMT strategies were implemented through instructional activities. This setting enabled me to explore the "how" and "what" aspects of CRMT's impact on student engagement (Creswell, 2013; Stake, 1995). I provided participants

with opportunities to describe how culturally responsive instruction influenced their mathematical learning and engagement.

As outlined in Figure 2, the research design included a careful selection of the site and participants, with attention to diversity, accessibility, and ethical considerations. Purposeful sampling was used to select eight CDLs from the geometry class I taught. Data were collected through semi-structured interviews, lesson reflections, classroom artifacts, and observational notes. The study used systematic, concurrent data collection and analysis methods, including constant comparison and iterative coding cycles (Malterud et al., 2016; Ravitch & Carl, 2021; Stake, 1995).

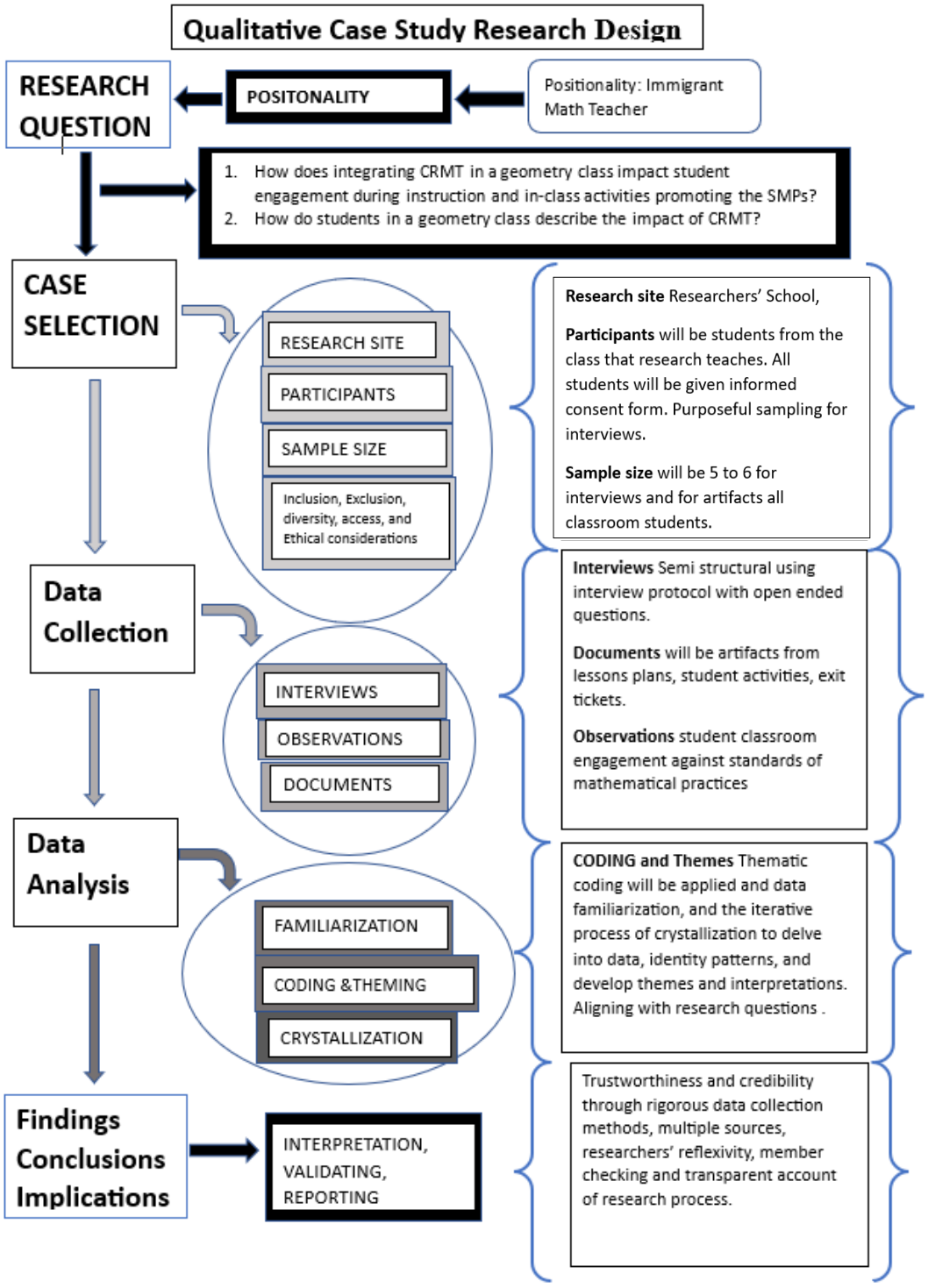
Themes were developed through thematic coding and refined using crystallization, an interpretive approach that supports the development of layered, multifaceted understandings of the data (Ellingson, 2009; Richardson, 2000), rather than seeking a single, unified truth. Crystallization allowed for the emergence of multiple perspectives and deeper insights into how CDLs experienced CRMT. Throughout the research process, attention was given to reflexivity, credibility, dependability, and transparency. “Strategies such as member checking, prolonged engagement, and thick description were used to enhance the trustworthiness of the findings.

This classroom was selected as the bounded case because it provided a rich context for exploring CRMT in practice. The class included a culturally and linguistically diverse group of students from multiple backgrounds, making it particularly well-suited for examining engagement through a CRMT lens. Geometry was chosen as the instructional focus because it offers opportunities for hands-on, visual, and collaborative learning, conditions that align closely with CRMT principles. Moreover, geometry often serves as a pivotal course in students’

mathematical identity formation, making it an ideal setting to study how culturally responsive strategies can influence participation, confidence, and connection to mathematical learning.

***Figure 2.***

*Robustness and trustworthiness of the research design*




*Note*. Adapted from study design by the researcher.

## Participants

As part of this research on CRMT practices, all students in the geometry class I taught were provided parent/guardian consent and student assent forms (Appendices A–B). Only the artifacts of students who returned signed consent forms were included in the study. To gain deeper insight into students' engagement with CRMT instruction, I used purposive sampling to select eight students for semi-structured interviews.

Purposive sampling involves the intentional selection of participants who are best positioned to provide meaningful and context-rich data aligned with the research purpose (Maxwell, 2014; Yin, 2002). Participants were selected based on their diverse cultural backgrounds and willingness to participate, ensuring that a range of perspectives was represented. This approach enabled the study to capture the complexity of student engagement and the varied ways culturally diverse learners experienced CRMT in a high school mathematics classroom (Merriam, 1998).

The study included eight culturally diverse students who voluntarily participated in interviews and submitted reflections. This purposefully selected sample reflected a range of cultural, racial, and linguistic backgrounds, supporting the CRMT framework's emphasis on student voice and identity. To maintain confidentiality, each participant is identified with a pseudonym (Appendix E includes only de-identified student artifacts):

- **Student A (**Stella**)** – A Black student who often shared her experiences navigating mathematics spaces as a minoritized learner.
- **Student B** (Angel)– A White student with prior success in math who provided insights on collaborative learning and peer support.

- **Student C** (Nancy)– An Asian student who demonstrated strong individual problem-solving skills and reflected on cultural expectations in education.
- **Student D** (Hailey**)** – A Brazilian student who valued visual and hands-on learning and expressed a preference for group-based instruction.
- **Student E** (Lucy) – A Brazilian student who recently joined the U.S. school system and shared experiences related to language learning and adjustment.
- **Student F** (Sam)– A Ukrainian background who discussed how prior educational systems influenced learning preferences.
- **Student G (**Paul**)** – A Hispanic student who emphasized the importance of real-world connections and cultural relevance in mathematics instruction.
- **Student H** (Raj) – An Indian student who appreciated structured instruction but became more engaged through student-centered strategies.

These student profiles provide contextual grounding for the themes presented in Chapter 4 (Findings) and illustrate how CRMT practices influenced engagement across varied student identities.

**Ethical Considerations**

Ethical practices were central to this study on CRMT, ensuring that research was conducted responsibly, respectfully, and in alignment with principles of equity and inclusion. Ethical considerations helped protect participants' rights, preserve the integrity of the research process, and create an environment of trust and respect, especially critical when working with culturally diverse learners (Marshall et al., 2021; Tracy & Hinrichs, 2017).

Throughout the study, ethical guidelines informed each stage of the research, from participant recruitment and consent to data collection, analysis, and dissemination.

Parent/guardian consent and student assent (Appendices A–B) were prioritized to ensure that students and their guardians clearly understood the purpose, procedures, and potential implications of the research. Only students who returned signed consent and assent forms were included, and all artifacts were de-identified before inclusion (Appendix E).

Efforts were made to respect students' cultural norms and values by seeking input from multiple stakeholders and by ensuring that research interactions honor the participants' identities and perspectives. Reflexivity was a key component of the research process. I maintained reflexive notes throughout the study to examine personal assumptions, power dynamics, and positionality as an immigrant math teacher. This reflective stance supported ethical decision-making and helped maintain a commitment to social justice.

By upholding standards of integrity, confidentiality, and cultural responsiveness, the study sought to contribute responsibly to the broader field of mathematics education and to promote ethical CRMT practices. The following sections detail additional safeguards, including confidentiality, respectful interaction, researcher reflexivity, and ethical approaches to data collection and analysis.

**Informed Consent and Voluntary Participation**

Parent/guardian consent, student assent, and voluntary participation were foundational to this study. These principles ensured that students and their guardians had the necessary information to make an informed decision about participation, including the study's purpose, procedures, potential risks and benefits, and the right to withdraw at any time without consequence (Moore et al., 2008).

All students enrolled in my geometry class received an introductory document explaining the study, including their rights as participants. The document emphasized that participation was

entirely voluntary and that students could opt out at any point without penalty or impact on their academic standing (Marshall et al., 2021; Moore et al., 2008). Students who chose to participate returned both signed student assent forms and parent/guardian consent forms (Appendices A–B).

Only data from students who submitted both forms were included in the study. The confidentiality of participant information was maintained throughout the research process, and all artifacts were de-identified prior to their inclusion in the study (Appendix E). Sample copies of the consent and assent forms are provided in Appendices (A–B).

**Relationships and Interactions with Participants**

Establishing transparent and respectful relationships with participants was central to this study. Students were assured that their participation would not affect their grades, classroom standing, or academic performance (Moore et al., 2008). Open communication was maintained throughout the study to foster trust and promote a comfortable environment. Participants were encouraged to share their thoughts freely, and their feedback was valued and taken seriously. This relational approach facilitated honest dialogue and meaningful engagement, supporting the integrity of the study (Tracy & Hinrichs, 2017).

**Data Collection Methods**

Yin (2009) emphasizes the importance of using multiple sources of data in case study research to enhance credibility and trustworthiness. In this study, data were collected through classroom observations, semi-structured interviews, and student reflections (Appendix F). Although student artifacts, such as exit tickets, worksheets, and projects, were collected and reviewed (Appendix F), they were not formally coded because interview and reflection data already demonstrated recurring patterns of engagement, collaboration, and cultural relevance, and the data had reached saturation. Lesson plans and field notes also contributed to a deeper

understanding of the context. Crystallization techniques were employed to iteratively examine the interviews and reflections, thereby supporting a nuanced understanding of how CRMT and the SMPs related to student engagement (Ellingson, 2009; Ravitch & Carl, 2021; Richardson, 2000).

**Research Site**

The study took place in my geometry classroom at a large, suburban high school in the southeastern United States. The school is part of a district recognized for its cultural and linguistic diversity. The site was ideal for this study because it offered access, familiarity, and rich opportunities to explore CRMT with a diverse group of students (Yin, 2002).

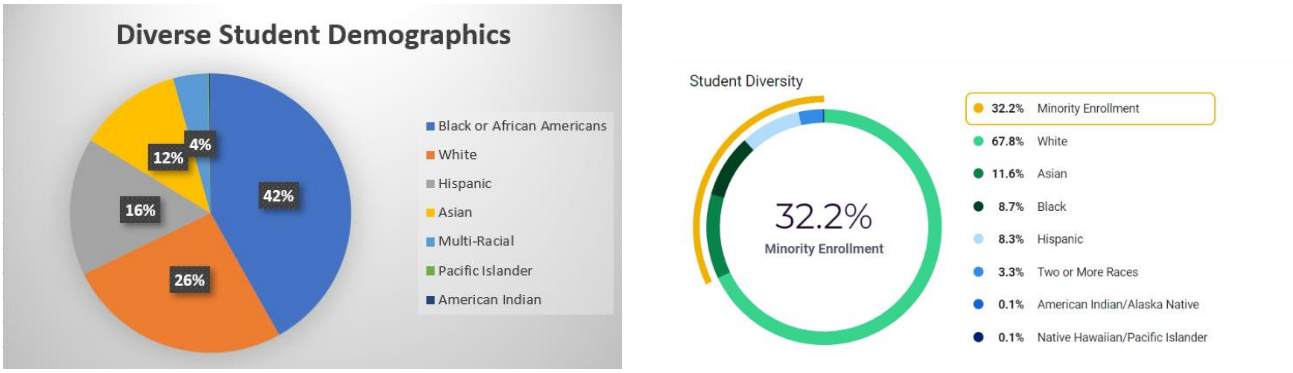
The school is equipped with modern instructional technology, including smartboards and laptops, and is supported by a leadership team dedicated to promoting equity, fostering student engagement, and achieving academic success. The school had recently expanded support for English for Speakers of Other Languages (ESOL) students, reflecting its commitment to inclusive education. Conducting research in my classroom enabled me to leverage existing relationships to create a safe environment for participants, while also maintaining awareness of ethical boundaries and reflexivity throughout the study.

To avoid redundancy, a concise account of the unit tasks and routines appears in Lesson Sequence and Task Design (see below), with figures and samples referenced in the appendices.

## Student Demographics

***Figure 3.***

*Student Demographics*




*Note*. Data adapted from Fulton County Schools, Student Diversity Demographics (2022), https://www.fultonschools.org/aboutus

Figure 3 presents the student demographic data for the school district and the specific high school in which the research was conducted. The district population in 2023 included approximately 26% White students and 74% students from minoritized backgrounds: 42% Black or African American, 16% Hispanic, 12% Asian (including Asian American), and 4% multiracial.

At the school where this study was conducted, 67.8% of students identified as White, and 32.2% identified as students from minoritized racial and ethnic backgrounds. These included 8.7% Black, 8.3% Hispanic, 11.6% Asian and Asian American, 3.3% multiracial, and a small percentage (0.1%) of American Indian/Alaskan Native and Native Hawaiian/Pacific Islander students. In my geometry classroom, approximately 50% of the students identified as culturally diverse learners.

## Documents

Artifacts included (a) student work products (e.g., Parallel City posters; annotated measurement tables; sketches), (b) lesson materials (task sheets, slides, criteria/checklists,

discussion stems), and (c) documentation of classroom activity (photos of products, anonymized participation maps, teacher field notes).

These materials were gathered at natural checkpoints (end of group work, consolidation, lesson close). Posters and 3-D models were photographed; written products were scanned and returned. Lesson packets and participation trackers were archived.

Consistent with the study's emphasis on student voice, artifacts functioned as corroborating evidence rather than a fully coded dataset. They were used to (a) verify patterns from interviews and lesson reflections (e.g., justification, precision, collaborative decision-making), (b) select de-identified exemplars to illustrate themes, and (c) inform analytic memos about CRMT enactment. When artifacts were referenced, brief SMP-aligned look-fors (modeling choices, assumptions, units, clarity of justification) supported consistency with the unit's design and instructional intent.

Appendix D contains complete lesson plans, and Appendix E presents de-identified student artifacts. While artifacts such as exit tickets, volume activity worksheets, and class projects were reviewed, they consistently reflected patterns already evident in the interview and reflection data. As the data began to saturate, recurring evidence of engagement, collaboration, and culturally responsive practices made formal coding of these additional artifacts unnecessary. Their primary role was to support contextual understanding and validate emerging themes. Appendix C includes an observation rubric to document engagement aligned with the SMPs

**Lesson Sequence and Task Design**

Instruction occurred within a short geometry unit designed with CRMT and aligned to selected SMPs. Lessons consistently emphasized relevance first, student agency with clear expectations, collaborative sense-making, and attention to precision, with recurring opportunities

for students to make sense of problems and persevere in solving them (SMP 1), construct viable arguments and critique the reasoning of others (SMP 3), model with mathematics (SMP 4), attend to precision (SMP 6), and look for and make use of structure (SMP 7). Three anchor tasks structured the sequence:

***Figure 4***.

*Culturally responsive artifacts- objects used in volume lessons to connect formulas to students' experiences*


*Note*. Adapted from study artifacts by the researcher.

- Volume of familiar objects (individual shapes). Students brought household items (e.g., cereal boxes, cans) and used them to compute volume, paying attention to measurement choices and precision, while connecting formal formulas to real-world experiences (see Figure 4; Appendix E for samples).
- Composite shapes modeling with Play-Doh. Students built composite solids, decomposed/recomposed them, and translated models into calculations of total volume and surface area (SMP 1; SMP 4; SMP 7). Representative materials and images are presented in Figures, along with de-identified student work in Appendix E.
- Parallel City poster project (angle relationships). In groups, students designed a city map with parallel lines and transversals, labeled corresponding/alternate

interior angles and justified measures to peers (SMP 3; SMP 6). A sample artifact is shown in Appendix E, Figure E1.

Each lesson began with a brief context primer, followed by small-group exploration with designated roles/talk moves, and concluded with whole-class consolidation and a short individual note to capture reasoning.

**Observations**

As the teacher-researcher, I conducted classroom observations during CRMT-based geometry lessons. Observations focused on students' engagement in instructional tasks, their collaborative interactions, and evidence of the SMPs in action, drawing on Merriam's (1998) observation protocols and Creswell's (2013) description of participant-observer roles. I maintained detailed field notes during and after class sessions. These notes captured student behaviors, participation patterns, and instructional dynamics relevant to culturally responsive practices (see Appendix C for the Observation Rubric).

**Interviews**

Semi-structured interviews (Appendix F) were conducted with eight student participants selected through purposive sampling. These interviews followed a protocol that explained the study's purpose, confidentiality protections, and participants' rights. When participants and their guardians gave consent, interviews were audio-recorded. For students who preferred not to be recorded, handwritten notes were taken.

I conducted all interviews in quiet, familiar locations, typically the classroom during non-instructional hours, to ensure that participants felt safe and comfortable. Each of the eight participants engaged in a one-on-one, semi-structured interview lasting approximately 15–25 minutes. I conducted these interviews after the instructional unit on volume and related CRMT

lessons had been completed, allowing students to reflect on their experiences with CRMT-based lessons. The interviews were guided by a protocol aligned with the research questions and grounded in the CRMT framework, focusing on students' perceptions of engagement, instructional strategies, and the cultural responsiveness of the mathematics content. Although the primary analysis focused on post-instruction interviews, initial reflection data gathered before the unit helped contextualize students' prior experiences and expectations, enabling a more comprehensive understanding of change over time.

With student consent, I audio-recorded all interviews and later transcribed them verbatim for analysis. I also took reflexive notes during and immediately after each session to document non-verbal cues, contextual observations, and preliminary analytic reflections. These student-centered interviews provided rich insight into how CRMT strategies supported student engagement and connections to mathematics. The full interview protocol, including sample questions, is included in Appendix F and was developed using established case study interview practices (Merriam, 1998; Stake, 1995; Yin, 2002).

**Data Analysis**

Qualitative data analysis involves more than summarizing information; it is an interpretive, iterative process that seeks to uncover meaning and patterns from participants' experiences (Creswell, 2013; Denzin & Lincoln, 2003). In this study, the analysis was designed to explore how CRMT influenced the engagement of CDLs in a high school geometry classroom. Using a CRMT lens, the goal was to illuminate connections between students' lived experiences and their mathematical engagement, while maintaining attention to rigor and reflexivity.

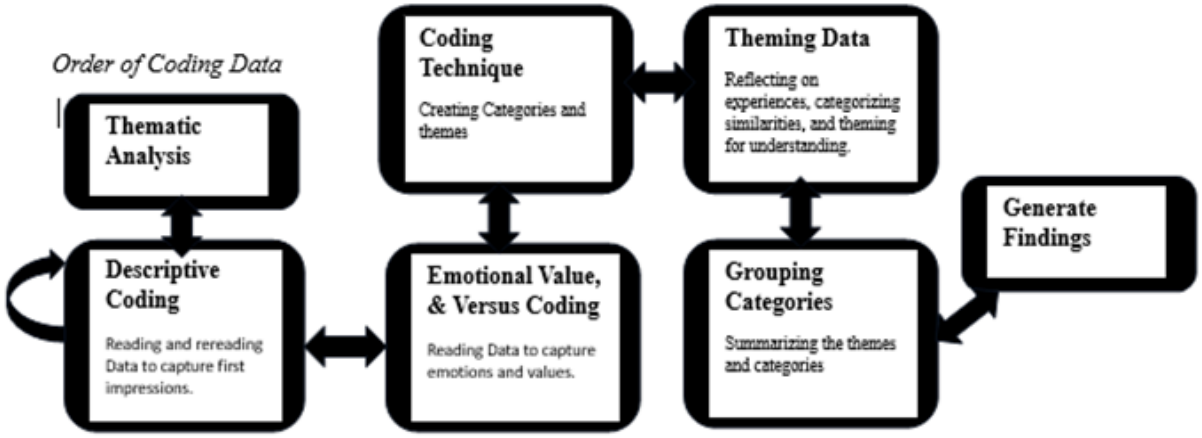
The analysis process was nonlinear and recursive, occurring concurrently with data collection. Interview transcripts and lesson reflections were uploaded to MAXQDA to support line-by-line coding and theme development. Data were organized in project folders by participant and by source type. The data were organized into folders corresponding to each participant and artifact type. A preliminary round of familiarization involved reading transcripts and reflections multiple times to gain an overall understanding of each participant's voice and the instructional context.

The data were then categorized according to their relevance to Research Question 1 (which explored how CRMT strategies impacted engagement during instruction and activities examined through the SMPs) and Research Question 2 (which focused on students' reflections about the impact of CRMT on their engagement and learning). This allowed coding to be structured in alignment with the purpose of each question while remaining open to emergent insights.

Figure 5 (shown below) outlines the order of coding used in the study, which began with descriptive and versus coding and progressed toward thematic grouping and interpretation.

***Figure 5.***

*Order of Coding Data*




*Note.* Adapted from Braun and Clarke's (2006) thematic analysis framework. Figure created by the author.

**Order of Data Analysis Procedures**

The data analysis followed a structured and sequential process that aligned with thematic analysis and ensured transparency in how raw data were transformed into findings. The analysis began with familiarization, during which I reviewed all interview transcripts, group reflections, student perception notes, and lesson reflections to gain an initial sense of patterns in student engagement and instructional experiences.

Following familiarization, I conducted line-by-line descriptive coding to capture first impressions and core ideas reflected in the data. I read all interviews, reflections, and perception notes in full and coded segments of the transcripts using MAXQDA. The initial descriptive codes were then compared, grouped, and refined across data sources through constant comparison. Once the descriptive codes were established, I applied emotional, value, process,

and versus coding to identify affective responses, beliefs, cognitive processes, and contrasts within student accounts.

Through this iterative coding process, related codes were organized into broader categories that represented recurring ideas in the dataset. These categories formed the foundation for theming, during which I examined relationships across categories to construct themes that captured the central findings for each research question. Throughout the analysis, I used crystallization to view the data from multiple perspectives, strengthening interpretive depth and overall trustworthiness.

**Coding and Thematic Analysis**

Coding was conducted using a combination of descriptive, emotional, versus, and process codes (Saldaña, 2022). Codes were clustered into categories aligned with CRMT and the three engagement dimensions (behavioral, emotional, and cognitive). The analytic process was also informed by Fredricks et al.'s (2004) tripartite framework of engagement. Behavioral engagement was evident in participation, persistence, and collaboration; emotional engagement was reflected in students' expressions of interest, confidence, or frustration; and cognitive engagement was associated with the depth of reasoning, problem-solving, and transfer of ideas. These dimensions guided the organization of codes alongside CRMT principles and the SMPs, ensuring that cultural relevance and mathematical reasoning were considered together in interpreting student engagement. They were also examined through the SMPs (e.g., perseverance, constructing arguments, and modeling with mathematics). In the initial round, descriptive coding helped identify general topics such as "student collaboration," "hands-on activity," or "confidence boost." Emotional and versus coding added depth by capturing contrasts in student responses (e.g., "bored vs. curious" or "teacher-directed vs. student-driven").

These initial codes supported the development of more conceptual categories through thematic coding.

An inductive codebook was developed from recurring patterns across transcripts and refined into broader categories aligned with CRMT and indicators of student engagement. Codes were clustered into broader categories aligned with CRMT principles and indicators of student engagement. For example, under Instructional Engagement, codes included "choice," "hands-on," "collaborative learning," and "visual tools." For codes linked to SMPs, classroom observations and reflections were used to identify practices such as "perseverance," "constructing arguments," or "modeling with mathematics."

This structure enabled parallel coding for engagement strategies and mathematical practices. Each transcript and reflection was coded line by line. Codes were grouped by research questions and refined through a constant comparative method. Thematic categories were developed by identifying overlapping codes and analyzing how they represented students' experiences and interpretations of CRMT. The following categories emerged and were later synthesized into themes reported in Chapter 4:

- Engagement through culturally responsive instruction
- Collaborative learning and peer support
- Confidence and student empowerment
- Cultural and real-world connections

Throughout the process, crystallization techniques (Ellingson, 2009; Ravitch & Carl, 2021; Richardson, 2000) supported reflexivity and triangulation across sources, enabling a rich and multifaceted understanding. The analysis remained attentive to context, participant voice, and the interactive meaning-making process between researcher and data (Merriam, 1998). The

trustworthiness of these findings was ensured through a series of rigorous strategies, described in the next section. The resulting themes are presented in Chapter 4 (Findings), and their interpretive implications are discussed in Chapter 5.

**Trustworthiness and Credibility**

To ensure the trustworthiness and credibility of this CRMT research, I implemented strategies recommended by qualitative scholars to enhance rigor and protect participants' rights (Lincoln & Guba, 1985; Merriam, 1998; Yin, 2009). One foundational strategy was the use of multiple data sources, including student interviews, lesson reflections, and classroom observational notes, which were analyzed through the iterative process of crystallization (Ellingson, 2009; Ravitch & Carl, 2021; Richardson, 2000). Crystallization enabled a multifaceted understanding of student engagement by integrating various perspectives.

I also engaged in ongoing critical reflection to identify and acknowledge assumptions and biases, especially given my dual role as teacher and researcher (Merriam, 1998). Recognizing the power dynamics inherent in this positionality, I created an environment of open dialogue that valued student autonomy and fostered honest participation. These strategies helped ensure that findings were grounded in authentic student voices.

Transparency was maintained through an audit trail that documented data collection procedures, analytic decisions, and theme development, enabling the study's process to be reviewed and evaluated. I also prioritized thick description, contextualizing the research site, participants, and findings to support the transferability of the study to similar educational settings (Lincoln & Guba, 1985; Merriam, 1998).

Merriam (1998) emphasized that qualitative research reflects a holistic and evolving reality, where credibility is established through detailed, coherent, and convincing descriptions

that allow readers to judge whether the findings "make sense" (p. 199). Her perspective guided this study's emphasis on thick description, reflexivity, and interpretive clarity. Stake's (1995) emphasis on triangulation, conceptualized in this study as crystallization, further supported the credibility of the interpretations by allowing insights to be examined from multiple vantage points. Merriam's (1998) assumptions align with the study's constructivist epistemology, which recognizes that meaning is shaped through ongoing interaction with social contexts. This interpretive stance is reflected in her assertion that:

> The researcher brings a construction of reality to the research situation, interacting with other people's constructions or interpretations of the phenomenon being studied. The final product of this study is yet another interpretation by the researcher of others' views filtered through his or her own (p. 22).

**Epistemological Stance**

The study is grounded in an interpretive/constructivist epistemology that values multiple realities and participant perspectives. Merriam (1998) categorized epistemological stances into four types: positivist/postpositivist, interpretive-constructivist, critical, and post-structural. She argued that the interpretive stance aligns most naturally with case study methodology because it views reality as socially constructed and ever-changing. This stance is consistent with qualitative research traditions that emphasize understanding meaning from participants' perspectives and interpreting experiences within their social and cultural contexts (Creswell & Poth, 2018; Merriam & Tisdell, 2016).

This constructivist perspective guided the design, implementation, and analysis of the study, with an emphasis on meaning-making through cultural, social, and contextual interactions. As a teacher-researcher, I worked to surface students' voices and experiences rather than impose

preexisting categories. This approach aligns with qualitative traditions that view the researcher as a co-constructor of meaning and knowledge through interaction with participants.

**Subjectivity in Research Studies**

Peshkin (1988) defined subjectivity as "the quality of the investigator that affects the results of the observational investigation" (p. 17). Rather than attempt to eliminate subjectivity, I took care to identify and monitor its influence throughout the research. Reflexivity was critical in maintaining sensitivity and transparency.

My positionality as a math teacher and immigrant from a culturally distinct background shaped my motivations and interpretations. Having witnessed the marginalization of culturally and linguistically diverse learners (CDLs) in advanced math contexts, I was committed to understanding how CRMT could counter these trends. I also acknowledged the resistance often encountered from colleagues when attempting to implement CRMT approaches, especially in collaboratively planned instructional settings. Addressing these issues was often challenging when colleagues resisted pedagogical changes such as implementing CRMT, particularly in collaboratively planned instruction.

By maintaining awareness of my subjectivity, I worked to ensure that interpretations were not imposed on student voices but rather emerged from their lived experiences and reflections. This interpretivist orientation supported the integrity, relevance, and authenticity of the study's findings on the impact of CRMT in a high school geometry class.

**Summary**

This chapter outlined the qualitative case study design used to examine how CRMT influenced student engagement in a high school geometry classroom. The study focused on eight culturally diverse learners and was conducted in the researcher's own classroom to provide

authentic and context-rich data. Data collection methods included semi-structured interviews, classroom observations, and student artifacts, which together provided a multi-perspective understanding of engagement. Data were analyzed inductively using iterative coding, thematic development, and crystallization techniques to identify recurring patterns related to CRMT strategies and the SMPs. Ethical considerations, including informed consent, confidentiality, and reflexivity, ensured the integrity of the study. The following chapter presents the findings that emerged from this analysis, organized around the research questions and thematic categories.

# CHAPTER 4 FINDINGS

This chapter presents the findings from a study that explored the impact of CRMT on student engagement in a high school geometry class. The following research questions guided the investigation:

1. How does integrating CRMT in a high school geometry class impact student engagement during in-class activities and instruction that promotes the SMPs?
2. How do students describe the impact of CRMT on their engagement, learning, and classroom experience in a high school geometry class?

I employed a CRMT framework (Bonner & Adams, 2012; Gay, 2010; Ladson-Billings, 1995) to explore these questions. For Research Question 1, which examined student engagement during CRMT instruction designed to promote the SMPs (NGA & CCSSO, 2010), the data included not only accounts of how students participated in lessons but also descriptions of instructional methods, engagement strategies, and classroom relationships that shaped their involvement. These additional details provided a deeper understanding of the classroom environment and the practices associated with active student participation.

For Research Question 2, which explored how students described the impact of CRMT on their engagement, learning, and classroom experience, the data highlighted students' references to teacher support, collaboration with peers, opportunities for independent thinking, and lessons that connected mathematics to their lived experiences. Through both research questions, students described engagement during lessons that included collaboration, cultural relevance, autonomy, and hands-on learning. These features were present in CRMT lessons that incorporated practices documented in prior literature (Gay, 2010; Ladson-Billings, 1995).

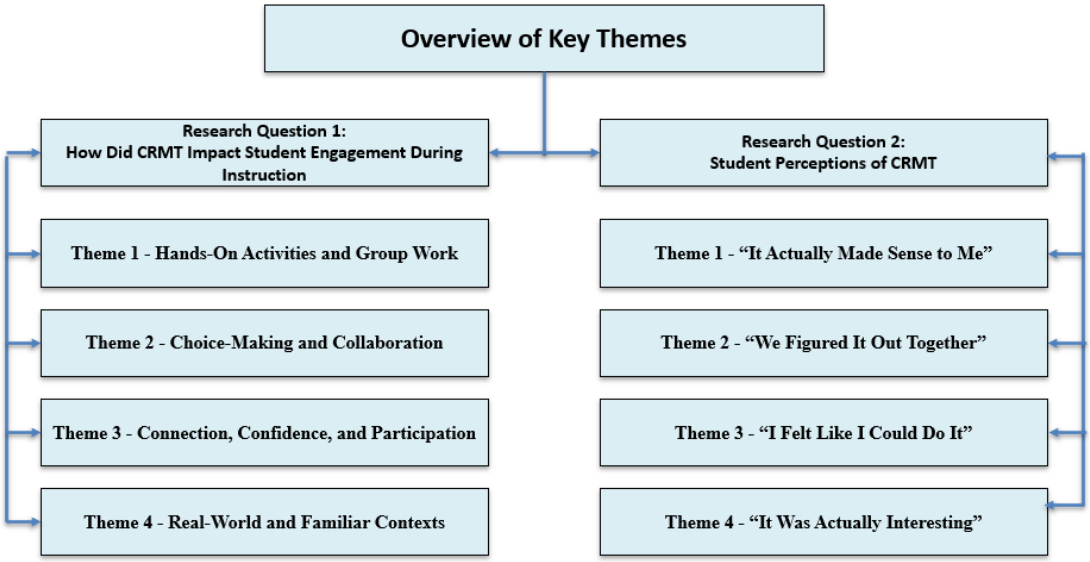
In this chapter, I present themes that emerged from student interviews and lesson reflections, with classroom observations and student artifacts reviewed informally for added context. Each theme relates to student engagement, participation, and learning in the geometry classroom and is organized according to its connection to the research questions.

## Overview of Key Themes

The findings from the CRMT lesson implementation are presented through themes developed using thematic coding of student interviews and lesson reflections, with additional details drawn from classroom observations and student artifacts. These themes expanded beyond the initial codes and were grouped into broader categories that reflected students' reported engagement, participation, and learning experiences. This approach provided a more comprehensive picture of how students interacted with CRMT instruction and the types of classroom experiences they described.

***Figure 6.***

*Visual Overview of Themes From Data Analysis*




*Note.* Figure created by the author.

Figure 6 offers a visual summary of the themes related to each research question, outlining the thematic structure that organizes the findings. Research Question 1 examined student engagement during CRMT-based geometry instruction. The themes describe what students were doing and experiencing during lessons, including participation, collaboration, hands-on work, and engagement with real-world contexts. These themes were based on both student interviews and lesson reflections, capturing engagement behaviors such as focus, persistence, and interaction.

Research Question 2 focuses on students' descriptions of their learning experiences during CRMT lessons. The themes present student accounts that include references to clarity, collaboration, confidence, and interest. The data for these themes come primarily from student interviews, where participants discussed CRMT strategies and their experiences in mathematics lessons.

The following sections present the findings for each theme, drawing directly from student interviews and lesson reflections. For each research question, the themes are illustrated with student statements and lesson examples that show how CRMT strategies were experienced in the geometry classroom. The presentation remains focused on describing what students reported or demonstrated, without interpretation, to provide a clear account of the evidence supporting each theme.

**Findings for Research Question 1: CRMT Lessons' Impact on Student Engagement**

Research Question 1 investigated the impact of CRMT on student engagement during high school geometry instruction. The findings are drawn from coded student interviews and lesson reflections, with student artifacts (e.g., classroom products, completed tasks) reviewed informally to illustrate engagement. Students described and were observed engaging in hands-on

activities, opportunities for collaboration and choice, integration of real-world and familiar contexts, and supportive classroom relationships. These features formed the basis for four themes that describe observed engagement with CRMT strategies. The following sections present each theme, accompanied by examples primarily drawn from coded data, supplemented by relevant artifacts.

***Theme 1: Hands-On Activities and Group Work:*** This theme highlights students' accounts of how hands-on materials, collaborative group activities, and physical engagement with mathematical concepts are incorporated into CRMT-aligned lessons. These instructional features were reported in student interviews and observed in lesson reflections across various student experiences.

***Figure 7.***

*Students created a culturally responsive Play-Doh composite shapes activity to understand volume*

*Note.* Pictures of the student artifact taken by the researcher

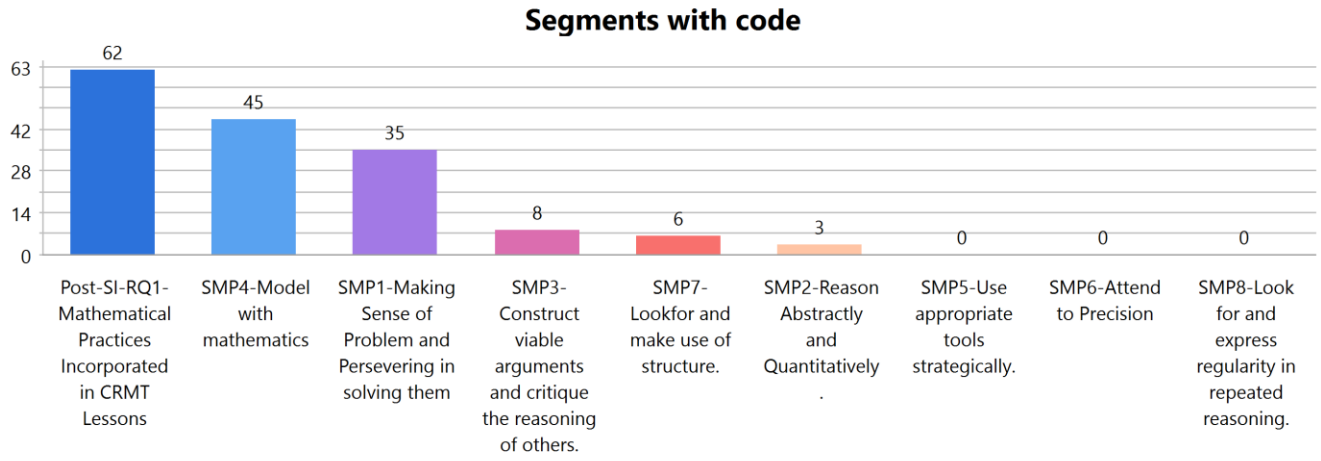
As shown in Figure 7, students constructed composite solids with Play-Doh to reason about the components of volume. In student interviews, students recalled the impact of collaborating with peers, using manipulatives, and engaging in geometry through real-world objects and tactile

activities, which involved experiential and collaborative learning elements. My lesson reflections documented similar patterns, noting the use of tangible tools, peer interaction, and shared tasks. Students were observed using physical objects to model geometric concepts, measure and compare real-life items, and check one another's work during group problem-solving.

Across both data sources, students consistently described their participation in tasks that involved peer collaboration and hands-on learning. They highlighted experiences with modeling with mathematics, using appropriate tools, and persevering in problem solving, and these same connections appeared across other themes as well. Observations further confirmed multiple ways in which students engaged in these active, collaborative learning opportunities. Together, these findings show that students not only brought their cultural experiences into the lessons but also drew on culturally shaped problem-solving strategies, such as their preferred ways of reasoning, organizing information, and modeling mathematical tasks.

***Figure 8.***

*Graph Representing the SMPs Embedded in Student Interviews*




*Note.* Figure created by the author.

***Student Interviews:*** In the post-lesson student interviews, students described their participation in collaborative, hands-on learning activities during the CRMT geometry lessons. As shown in Figure 8, these responses emphasized teamwork, physical modeling of mathematical concepts, and interactive learning, making geometry lessons feel tangible and accessible. The activities students referenced included peer collaboration, real-world connections, and student-centered learning opportunities. Student and lesson reflection accounts also reflected engagement with key the SMPs, including making sense of problems, modeling with mathematics, and reasoning through peer dialogue.

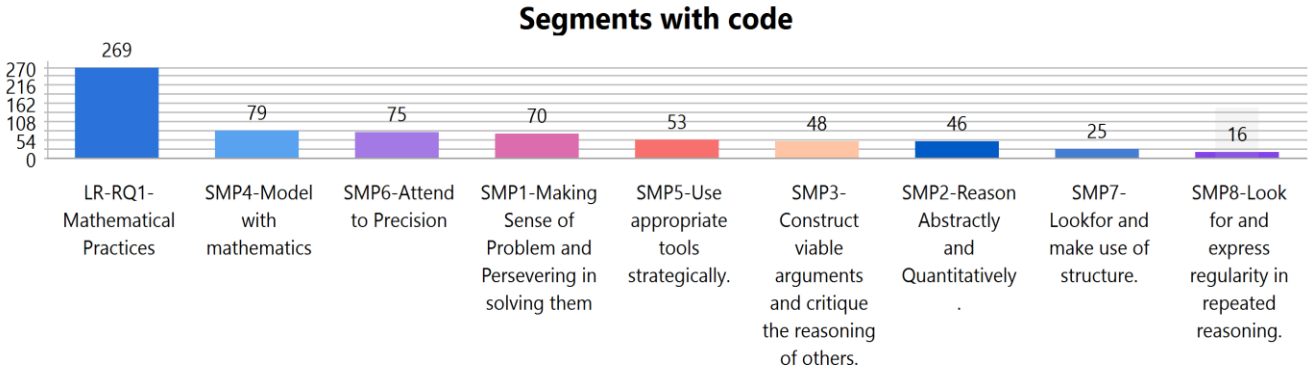
Students frequently mentioned group work and problem-solving tasks that involved physical models. Lucy explained, “I like it because we were able to work in teams,” while Sam noted, “Since it was hands-on, you had to have, like, full concentration.” Students persisted with complex tasks and relied on group dialogue to solve unfamiliar problems. Raj also said, “I like the lesson because it was fun, and it was very different,” in response to a geometry lesson where Play-Doh was used to model composite shapes. Students described that working with familiar, tangible materials helped them understand geometry concepts. Students also recalled group discussions that required them to reason and provide explanations. Paul said, “I like the lesson because it made me think,” while Nancy noted, “Since the group I was working with was not very cooperative, I did not feel very comfortable.” These examples included aspects of constructing viable arguments and critiquing others' reasoning (SMP 3) and described how peer dynamics affected participation in collaborative learning.

In addition to the interview responses, student-created artifacts provided further evidence of these instructional features. In the Play-Doh Composite Shapes activity and the Parallel City projects, students applied mathematical concepts to objects from their everyday environments,

such as cereal boxes and sports equipment, which they brought from home for measurement tasks. Student interviews and artifacts repeatedly referenced collaboration, physical modeling, and the integration of real-world objects into geometry lessons. These features were present across multiple lessons and were frequently mentioned by students in relation to their participation and comprehension. Lesson reflections echoed many of the same points noted in student interviews, particularly regarding the value of tangible materials and peer collaboration.

***Figure 9.***

*Graph Representing the SMPs Embedded in Lesson Reflections*




*Note.* Figure created by the author.

***Lesson Reflections:*** Figure 9 illustrates how my lesson reflects students' engagement in collaborative, hands-on mathematics tasks during CRMT geometry instruction. These lesson reflections reflected how students interacted with physical materials, applied mathematical concepts to real-world contexts, and worked with peers during problem-solving activities.

In lessons involving real-world volume calculations, students worked on tasks that involved making sense of problems and continuing to work toward solutions. One reflection noted:

> The challenge of finding volumes with and without the white portion of the coconut encouraged perseverance in solving complex problems. I watched students break down the problem into steps, draw diagrams, test strategies, and revise calculations until they made sense. Their persistence was impressive and authentic.

Students noted that tangible materials made geometric concepts easier to understand before moving into group problem-solving. Another reflection stated, "Students were tasked with designing and measuring composite 3D shapes, which required breaking the task into manageable steps." In these moments, students used tangible, culturally meaningful items to represent and work through geometric concepts.

Modeling with mathematics (SMP 4) was the most frequently mentioned topic in the lesson reflections. Students often used tangible objects to explore geometric concepts. For example, I wrote, "Using coconuts and sports balls as models for spheres, connected abstract formulas to tangible, real-world objects." The use of coconuts, which students recognized from home or cultural settings, was incorporated into lessons alongside mathematical formulas. In another reflection, I noted, "Tracing the ball to approximate the diameter demonstrated creative mathematical modeling without precise tools." These moments documented how students used real-life and culturally responsive items to represent geometric concepts.

I also observed students reasoning abstractly and quantitatively (SMP 2) during lessons in which they used volume formulas. One reflection stated, "Students applied the sphere volume formula to celestial objects (such as the moon) and everyday objects (such as sports balls and coconuts), reasoning quantitatively about the relationships between diameter, radius, and volume." Another entry recorded students combining measurements to calculate the total volume of composite shapes.

> Collaborative discussions reflecting SMP 3 (Construct viable arguments and critique the reasoning of others) were also present. I observed instances where students discussed and questioned one another's solutions. In one reflection, I wrote, Students challenged one another about using the pi symbol versus 3.14 on their calculators, which led to a discussion on approximation versus exact values. This conversation reflected their attention to precision and their ability to question each other's reasoning in a respectful and mathematically productive way.

Additional lesson reflections documented student use of tools and attention to precision. For SMP 5 (Use appropriate tools strategically), I recorded, "Students effectively used rulers for measurements and Play-Doh for modeling, demonstrating strategic use of tools to represent their composite shapes accurately." Attention to precision (SMP 6) appeared in moments like, "Students engaged in a detailed discussion about the difference between height and slant height when calculating the volume of a cone." In other entries, I noted patterns of repeated reasoning (SMP 8) as students applied volume strategies across distinct types of shapes.

Across these lesson reflections, students worked collaboratively, used hands-on modeling, and incorporated real-world examples during CRMT instruction. Observations across multiple lessons documented student participation in tasks that involved peer interaction, hands-on materials, and culturally responsive contexts during CRMT instruction. Across these lesson reflections, students described lessons that involved physical participation and peer collaboration. In both student interviews and lesson reflections, these activities were described as interactive and collaborative, with students using tools, modeling with mathematics, and persevering in problem solving during CRMT-based instruction.

***Theme 2: Choice-Making and Collaboration:*** This theme highlights the ways students

described having voice and agency in their learning through opportunities to make decisions, share strategies, and collaborate with peers. Choice-making referred to moments when students could select materials, decide on approaches, or create their own representations of mathematical ideas. Collaboration involved peer-to-peer explanation, group problem-solving, and shared responsibility for completing tasks. Together, these accounts demonstrate how CRMT lessons shifted participation from teacher-directed instruction to student-centered learning experiences. The repeated student quote, “We got to choose and learn together,” captured how students connected choice and collaboration during CRMT-based geometry lessons.

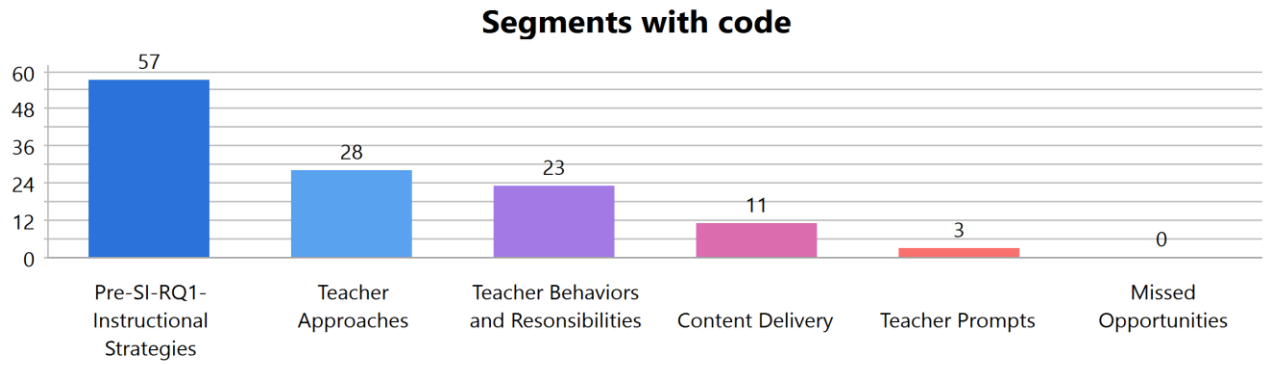
This section presents students' accounts of how opportunities for choice and collaboration shaped their participation and engagement during CRMT lessons. Students described moments where they could make decisions about materials, approaches, or roles, as well as experiences of working together to solve problems and share ideas with peers. Drawing on student interviews and lesson reflections, I gathered how specific teaching practices influenced student participation, motivation, and engagement. Students described instructional approaches as creating active engagement, such as opportunities for choice and collaboration, while other approaches provided fewer chances for participation. Students gave examples of lessons where strategies included clear roles, opportunities for participation, and peer interaction, as well as examples where unclear group roles, inconsistent support, or a lack of follow-up questions were mentioned. The coded data included examples from students who demonstrated both active and limited participation during lessons.

The data from student interviews and lesson reflections describe instructional approaches that students said supported their engagement and helped maintain a positive classroom environment. Students also described instances of limited engagement, often citing unclear group

roles, inconsistent support, or a lack of follow-up questions. By reflecting on both successful practices and areas for growth, I present a more comprehensive picture of how CRMT instruction shaped student learning experiences. Figure 10 presents instructional strategies used before CRMT implementation, while Figure 11 illustrates those used after CRMT practices were adopted. Students described opportunities for choice and peer interaction during lessons, including explaining their reasoning, discussing peers' ideas, and collaborating on problem-solving.

***Figure 10.***

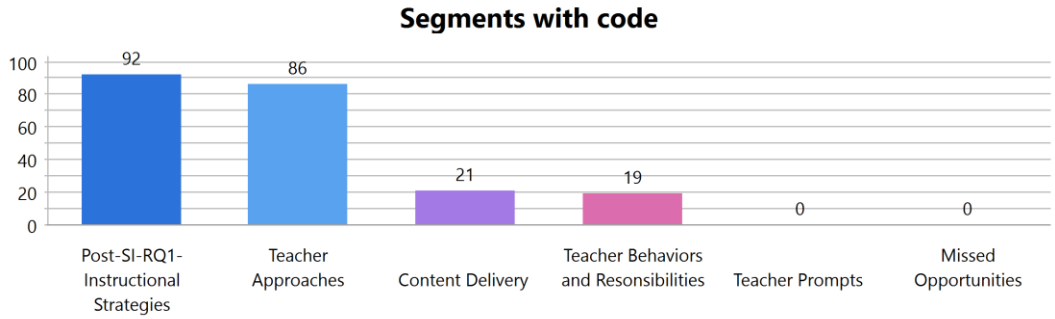
*Graph Representing Instructional Strategies From the Pre-CRMT Lessons*




*Note.* Figure created by the author.

***Figure 11.***

*Graph Representing Instructional Strategies Post-CRMT Lessons*



*Note.* Figure created by the author.

***Student Interviews:*** In the student interviews, responses described how instructional strategies influenced engagement and learning during CRMT geometry lessons. As shown in Figure 10, prior to the implementation of CRMT, students described experiencing a range of teacher-centered strategies. The most frequently mentioned categories included teacher behavior and responsibility, teacher approaches, content delivery, and teacher prompts. Students often described how these elements shaped their learning and participation. In the pre-CRMT student interviews, students emphasized traditional instructional approaches, as they may not have known or experienced opportunities for choice and collaboration. Before CRMT, as shown in Figure 10, students described the teacher's role as central to their learning experience. They mentioned teacher support through check-ins, relationship-building, and attention to time and pacing. Students described learning through structured, teacher-led methods such as direct instruction and note-taking. Lucy shared, "I like to learn with notes and lessons and write the meaning of things," reflecting a preference for familiar, teacher-centered formats.

After implementing CRMT lessons, student interviews included more frequent and detailed references to instructional strategies (see Figure 11). Mentions of teacher behavior and support remained common. Raj shared, "Mrs. K talks to us equally, and we can all speak without any barrier," describing a collaborative environment that enabled students to share strategies and work with peers.

Students described instructional strategies in CRMT lessons as interactive and student-centered. Many reported that opportunities to choose materials or participate in creative, open-ended activities increased their engagement. Hailey said, "I like it because it was fun and it was very different," while another explained:

> Personally, I just think that maybe if we could choose, like, what we were using for the materials and what shapes we wanted to do. It would have been better because we would be more into it if it was our own stuff
>
> (Angel, interview, fall 2024).

Students also noted that during the Play-Doh Composite Shapes Activity, they were able to create their own composite figures, which gave them a sense of ownership in the task. In other lessons, students selected objects from home, such as cereal boxes or sports balls, to calculate volume, emphasizing that having a choice of materials made the work feel more personal and engaging. In these student interviews, students associated opportunities for autonomy and voice with increased interest and participation. Students shared challenges that limited their engagement, such as unclear instructions during multi-step tasks. Nancy noted that more written directions would have helped, explaining that they were unsure of what to do and found it challenging to stay engaged without clearer expectations. Student responses also described differences in participation that they connected to the level of support provided during lessons.

Students described how collaboration supported their understanding. Sam said, "I definitely am a person who likes group work more; you just learn from each other, and it is better that way." In their responses, students described collaborative learning and creating their own content as supporting their understanding and sense of ownership in their work.

Students frequently cited collaborating with peers as a key part of their learning during CRMT lessons. Paul noted, *"*Yeah, of course. It is better to learn with another person, right? It is easier." Students also described limits of peer work when group roles or participation were uneven. Nancy reflected:

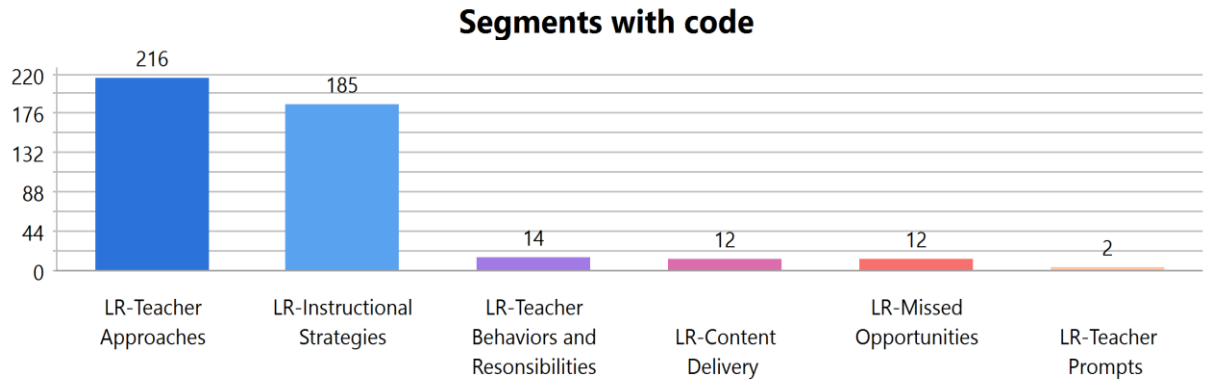
> I liked the participation part, but from my personal perspective, since the group I was working with was not very cooperative, I did not feel very comfortable. However, the overall activity was good. And you could communicate more with it
>
> (Nancy, interview, fall 2024).

Students also described the impact of culturally responsive and project-based learning on their engagement. Sam reflected on a lesson by saying, “It is a more interactive project you can actually have fun doing,” referring to the Parallel City Poster Project. In this project, students selected their own community landmarks, street names, and artifacts to represent parallel lines, which reinforced the sense of choice and cultural relevance. Stella commented, “We understand more about our culture through the things we did not know before in math. We know it now.” These lesson reflections described culturally responsive tasks that students said connected to their own identities and experiences.

Overall, students described CRMT-aligned instructional strategies as supporting their participation and interest. They highlighted collaboration with peers and opportunities to make choices, such as designing their own shapes, selecting familiar objects for measurement, or personalizing the Parallel City project, alongside culturally connected content and interactive learning.

***Figure 12.***

*Graph Representing Instructional Strategies Post-CRMT From the Lesson Reflections*




*Note.* Figure created by the author.

***Lesson Reflections:*** As shown in Figure 12, student reflections and my lesson reflections documented how instructional strategies unfolded during CRMT geometry lessons and described their connection to student engagement. Across multiple lessons, patterns in teaching practices included collaboration, opportunities for students to choose materials and approaches, and structures that supported shared decision-making. These lesson reflections described instructional moments in which students participated, including examples of strategies they found helpful and areas they found challenging.

In the lessons on volumes of objects, students brought in familiar objects, such as canned food, cereal boxes, or bread packaging, and used them in measurement tasks. Lesson reflections recorded that students explained their approaches to peers while working with the objects they had chosen. My instructional notes frequently included examples of collaborative learning. In these lessons, students worked in groups to solve geometry problems, share reasoning, and check one another's calculations. One reflection stated, "Students were encouraged to communicate with peers and substantiate each other's calculations. They actively participated in discussing

their findings and deliberating on erroneous calculations." Lesson reflections described challenges when students who needed more support were placed in groups where they participated less actively: "I should have designated the groups; students who required additional scaffolding were placed in a high-performing group, which rendered them somewhat apprehensive."

Attention to precision was another recurring instructional focus. I often emphasized accuracy in measurements and mathematical communication. Another entry emphasized the importance of mathematical precision, noting how students were asked to round answers to three decimal places and measure carefully. These lessons included real-life applications where accuracy was emphasized, such as design or construction tasks. These expectations often played out through peer checking and shared solution reviews, keeping the focus on students' collaborative reasoning.

Lesson reflections indicated that explicit support with tools (e.g., calculator functions) helped students participate in group tasks and make informed choices about problem-solving approaches. For example, one entry noted, "Doing a lesson on using a calculator would have been helpful, as students needed help raising powers or using the pi function for exact answers." In another reflection, I wrote, "Modeling the derivation of the formula would have had a better impact if students also had models in their hands, and although they observed my demonstration, students would have benefited from manipulating their physical models."

Entries in the lesson reflections described students discussing which representations to use (e.g., a loaf of bread for prisms or liquid transfer for pyramids) as they explained approaches to one another. In one lesson reflection, I wrote, "I guided the students in deriving the formula for the volume of a prism by connecting it to the area of the base and the height. I modeled using

a loaf of bread." For pyramids, I noted, "I guided the students in deriving the formula for the volume of pyramids by pouring liquid into a prism and a pyramid to demonstrate the 1/3 relationship."

Lesson reflections described moments when unclear group roles or task steps limited participation. One reflection stated, "I reinforced the importance of mathematical precision by requiring students to round answers to three decimal places and measure carefully." Another recorded, "Some students became briefly sidetracked discussing their cereal preferences. I gently diverted their conversation back to the activity."

In lesson reflections, unclear expectations for shared work led to uncertainty about how students should proceed together. One entry noted, "While most students rated their engagement with the activity highly, some cited confusion and a lack of instructions as reasons for a lower rating." Student interviews and lesson reflections described culturally responsive, student-centered activities combined with clear and supportive teaching strategies as part of CRMT classrooms.

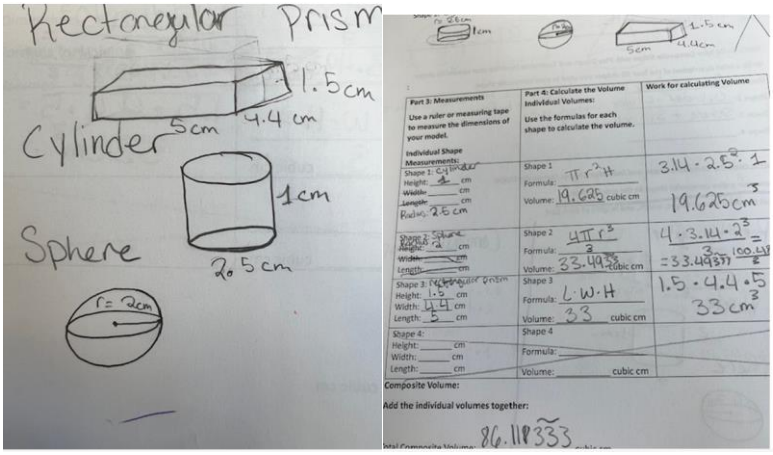
Lesson reflections highlighted opportunities to choose materials/approaches and to collaborate with peers as central to participation. Students' accounts described decision-making, peer discussion, and shared problem-solving as features that supported engagement during CRMT lessons. Overall, students described opportunities for collaboration and choice as contributing to the relevance and interest of the lessons. Students' accounts and lesson reflections consistently described decision-making and peer discussion. They shared problem-solving strategies, with examples of constructing arguments, critiquing reasoning, and applying strategies observed during CRMT lessons.

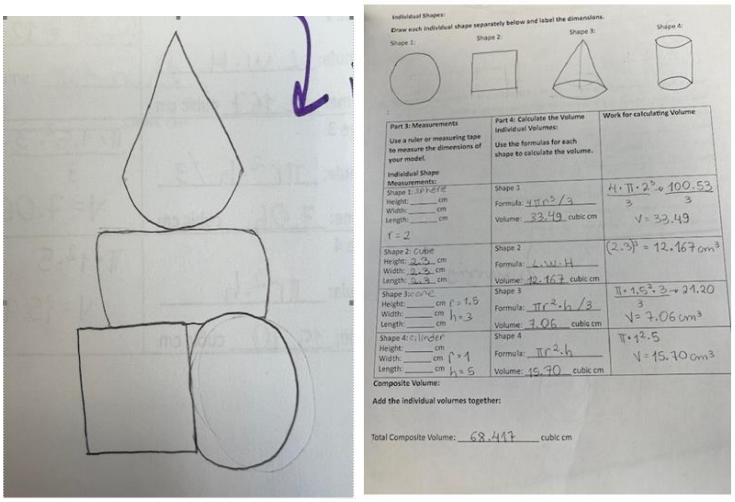
***Theme 3-Connection, Confidence, and Participation:*** This theme emerged from student interviews and lesson reflections, describing how CRMT strategies supported students' confidence and participation. These strategies included opportunities to participate and scaffolded instruction that supported confidence. Sam explained, "I felt like I could do it," reflecting the increased confidence and sense of belonging students described during CRMT lessons. Students frequently reported feeling more confident and motivated when lessons included clear guidance and provided explicit opportunities for contribution. Students linked these opportunities to feel more capable. Raj reflected:

> It definitely helped me a lot more because I actually got to choose the manipulatives and work instead of just having things thrown at me. I liked that we could do it our own way and figure out the process
>
> (Raj, interview, fall 2024).

***Figure 13.***

*Students Applying Volume to Self-Created Shapes*





Individual Shapes:

Draw each individual shape separately below and label the dimensions.

Shape 1: Shape 2: Shape 3: Shape 4:

| Part 3: Measurements | Part 4: Calculate the Volume of Individual Volumes: | Work for calculating Volume |
|---|---|---|
| Use a ruler or measuring tape to measure the dimensions of your model. | Use the formulas for each shape to calculate the volume. | |
| Individual Shape Measurements: | | |
| Shape 1: Sphere<br>Height: _____ cm<br>Width: _____ cm<br>Length: _____ cm<br>r = 2 | Shape 1<br>Formula: $4\pi r^3/3$<br>Volume: 33.49 cubic cm | $4 \cdot \pi \cdot 2^3 \div 100.53$<br>3<br>V = 33.49 |
| Shape 2: Cube<br>Height: 2.3 cm<br>Width: 2.3 cm<br>Length: 2.3 cm | Shape 2<br>Formula: L.W.H<br>Volume: 12.167 cubic cm | $(2.3)^3 = 12.167 cm^3$ |
| Shape 3: Cone<br>Height: _____ cm r = 1.5<br>Width: _____ cm h = 3<br>Length: _____ cm | Shape 3<br>Formula: $\pi r^2 \cdot h/3$<br>Volume: 7.06 cubic cm | $\pi \cdot 1.5^2 \cdot 3 \div 21.20$<br>3<br>V = 7.06 $cm^3$ |
| Shape 4: Cylinder<br>Height: _____ cm<br>Width: _____ cm r = 1<br>Length: _____ cm h = 5 | Shape 4<br>Formula: $\pi r^2 \cdot h$<br>Volume: 15.70 cubic cm | $\pi \cdot 1^2 \cdot 5$<br>V = 15.70 $cm^3$ |

Composite Volume:

Add the individual volumes together:

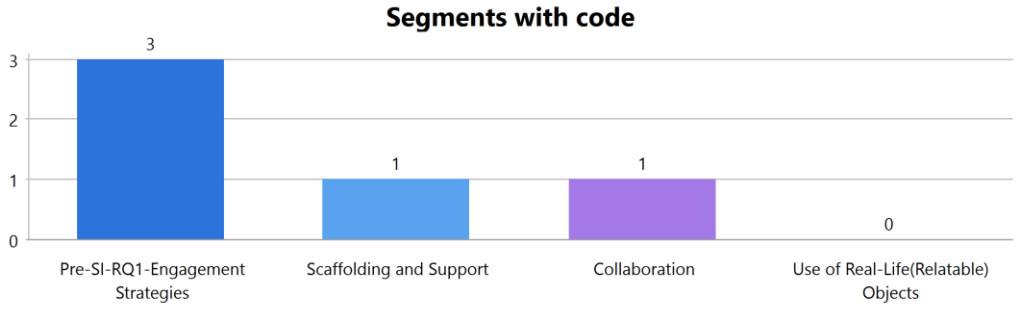
Total Composite Volume: 68.417 cubic cm

*Note.* Student Artifacts collected by the author

Figure 13 illustrates students transferring conceptual understanding into self-generated models. Across the data, students linked CRMT strategies to their participation. They described these features as helping them understand lessons more easily and staying interested. Lesson reflections reported similar observations during interactive, student-centered tasks. In their accounts, students emphasized clear guidance, opportunities to share ideas, and supportive structures that encouraged participation.

***Figure 14.***

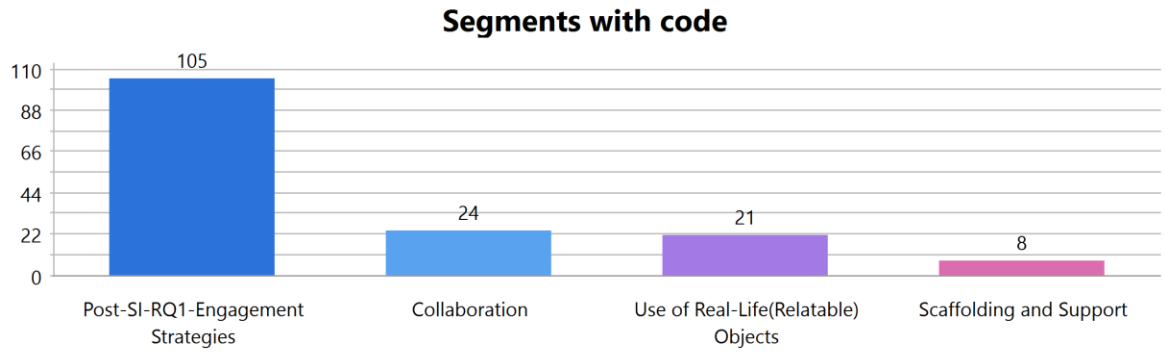
*Graph Representing Engagement Strategies Before CRMT Lessons*




*Note.* Figure created by the author.

***Figure 15.***

*Graph Representing Engagement Strategies After the CRMT Lessons*




*Note.* Figure created by the author.

***Student Interviews:*** This section presents student interview responses about CRMT engagement strategies and their connection to participation in math lessons. Figures 14 and 15 highlight the engagement strategies before and after the administration of CRMT lessons. Students found lessons easier to understand, which encouraged them to share ideas and participate more openly. Sam said, "I definitely am a person who likes group work more because I like other people's, like, ideas and work, and you just learn off of each other, it is better that way, in my opinion."

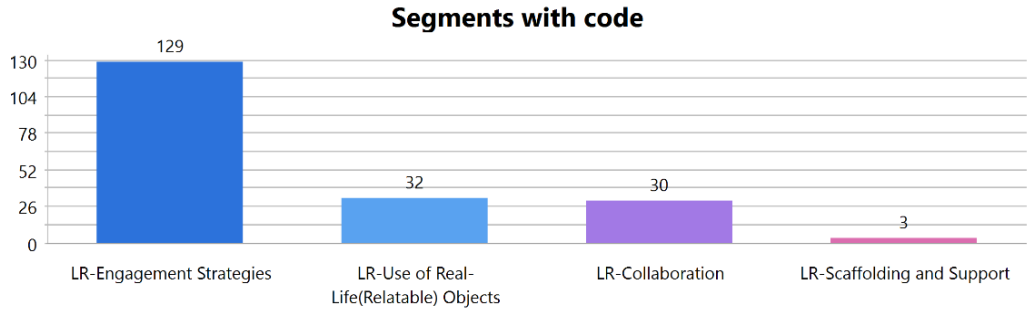
Students noted that clear instructional support and flexibility were present in lessons where they participated more actively. In contrast, others described unclear lesson instructions, making it more challenging to engage. Nancy explained, "The instructions were good, but they were a little too fast. I think, like, instructions on the paper directly would have also been quite useful." Students' comments included references to pacing, clarity, and the use of multiple forms of guidance in lessons where they were actively involved.

When asked to reflect on their experiences, most students preferred the CRMT lessons to traditional instruction. Angel stated, "These activities are more engaging and motivating

compared to traditional math lessons focused on notes and textbook work." Student interviews described CRMT engagement strategies as motivating and supportive of participation. Students explained that they were more willing to contribute when lessons included clear guidance and opportunities to share their thinking.

***Figure 16.***

*Graph Representing Engagement Strategies Post-CRMT Lessons*




*Note.* Figure created by the author.

***Lesson Reflections:*** My lesson reflections documented how CRMT engagement strategies supported students' confidence and participation during the lessons. These lesson reflections, as shown in Figure 16, describe how students used engagement strategies to interact with the content and with one another during lessons that incorporated culturally responsive strategies.

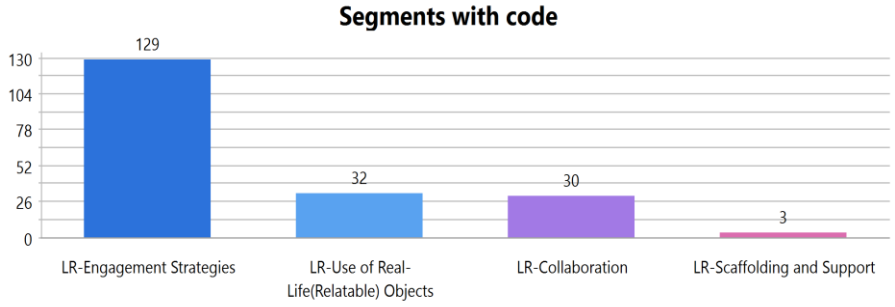
Students described feeling more confident when tasks included clear, concrete examples that helped them understand abstract concepts. Lesson reflections noted that students engaged more when activities allowed them to explain their reasoning and check their understanding with others. Lesson reflections noted that students gained confidence when they shared their reasoning and checked their understanding with peers. One entry recorded, "Students were encouraged to communicate with their peers and validate each other's calculations." This peer-

checking process encouraged accountability and helped students explain why their answers made sense."

Lesson reflections indicated that students needed more explicit support and guidance, particularly when tasks involved new tools or unfamiliar content. Without this scaffolding, students hesitated to participate fully; however, more explicit guidance increased their confidence in engaging in the activity. For example, I wrote, "A lesson on using a calculator would have been helpful, as students needed help raising powers or using the pi function for exact answers." Lesson reflections highlighted that setting high expectations and providing a clear structure supported students' confidence and participation. One entry emphasized this: "High expectations were set for precision in measurements and calculations. Students were given time to analyze the volume calculation with slant height to allow higher thinking." Another described how structure helped students stay focused: "Setting expectations high was very beneficial as students religiously followed instructions." Lesson reflections emphasized how scaffolding, clear structure, and opportunities to explain reasoning supported students' confidence and participation. Across both student interviews and lesson reflections, students described staying engaged when they felt prepared, guided, and encouraged to contribute.

***Figure 17.***

*Graph Representing Engagement Strategies Post-CRMT Lessons*



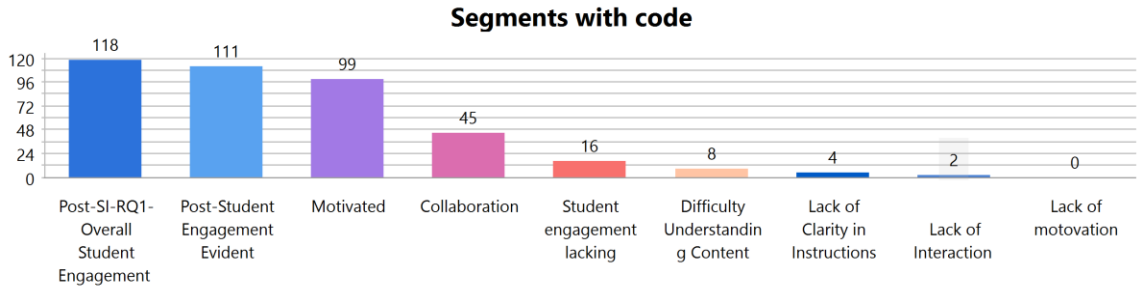

*Note.* Figure created by the author.

***Theme 4-Real-World Relevance:*** This theme emerged from student interviews and lesson reflections, which described how real-world and culturally responsive connections influenced engagement during CRMT geometry instruction (see Figure 17). Students emphasized that lessons connected to familiar objects, everyday experiences, or culturally meaningful contexts felt more relevant and engaging. These connections motivated them to participate more actively and helped them see mathematics as applicable beyond the classroom.

The data included instances of both active participation and reduced involvement. Students reported increased participation in lessons that incorporated cultural relevance, familiar objects, and tangible learning materials. The following sections present student interviews and lesson reflections about when and how students participated in lessons that connected math to real-life and culturally meaningful contexts. In both student interviews and lesson reflections, students explained that familiar examples encouraged them to contribute, persist with challenging tasks, and recognize the value of applying mathematics beyond the classroom.

***Figure 18.***

*Graph Representing Overall Student Engagement Post-CRMT Lessons*




*Note.* Figure created by the author.

***Student Interviews:*** Figure 18 summarizes the patterns from post-lesson interview responses, in which students described their experiences of engagement and disengagement during CRMT-aligned geometry lessons. Students mentioned connections to familiar experiences

and everyday context when describing these lessons. Responses included references to firsthand experiences, opportunities to express ideas, and lessons that felt inclusive. Raj commented on the interactive nature of the lessons, stating, “I like it because it was fun and very different,” and “I like that it was interactive.”

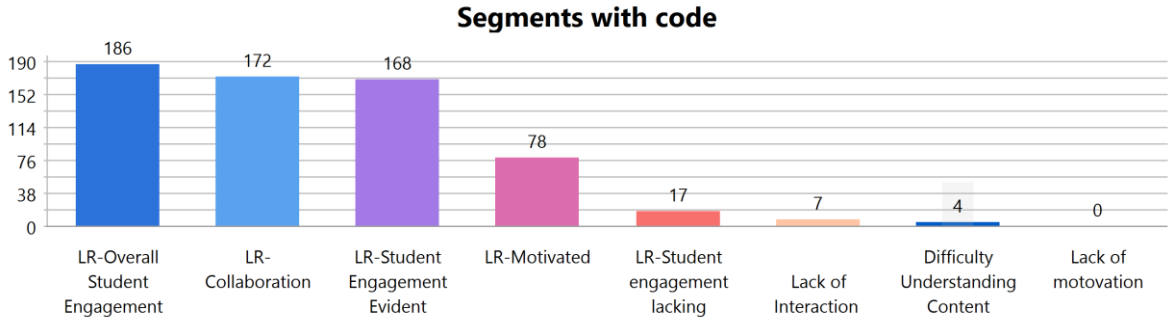
Students described creating their mathematical models or working with familiar materials during lessons. Lucy stated, “It helped me because they were my own shapes. There was something that I created, so obviously, I would understand it better.” Paul mentioned:

> One lesson used cereal boxes to teach volume, and I remember thinking, “Hey, I use these at home.” I was measuring and calculating stuff I actually see in the kitchen. It did not feel like math class. It felt like something useful, like I could do this in real life, besides passing a test. That made me care more
>
> (Paul, interview, fall 2024)

In the student interviews, students highlighted lessons with real-world applications and personal connections as the times when they participated more and found mathematics meaningful.

***Figure 19.***

*Graph Representing Overall Student Engagement From Lesson Reflections Post-CRMT Lessons*




*Note.* Figure created by the author.

***Lesson Reflections:*** Figure 19 also reflects patterns observed in lesson reflections that describe student engagement during CRMT geometry lessons. Across multiple lessons, students showed curiosity and participated actively when tasks incorporated real-life connections and interactive elements.

Lesson reflections frequently described students using rulers, calculators, and everyday objects such as cereal boxes, canned goods, and sports balls to explore mathematical concepts like volume. Lesson reflections noted that students connected the content to items they recognized or had brought from home. One entry stated, "Students used rulers, calculators, and everyday objects such as cereal boxes, canned goods, and sports balls to explore mathematical concepts like volume." Real-world examples such as cereal boxes and sports balls were recorded as part of lessons on volume and other concepts. Another reflection noted, "Students connected the math content to something they recognized or had brought from home."

Challenges were noted when students struggled to connect abstract content to real-world examples. In one entry, I wrote, "While students recognized cones easily, they had difficulty relating to pyramids. Students more easily recognized cones than pyramids and did not connect as readily to the examples used."

In the lesson reflections, students described engagement during lessons that incorporated CRMT principles. These lesson reflections illustrate how CRMT strategies, such as interactive tasks and real-world connections, fostered student interest and active participation. Lesson reflections also recorded students making personal connections to tasks when objects from diverse cultures were used. On reflection, noted:

> Students lit up when we used objects from diverse cultures. They connected the math task to something personal and were eager to share what they knew. It was no longer only

about solving problems; it became an opportunity to bring their background into the classroom. That really mattered to them.

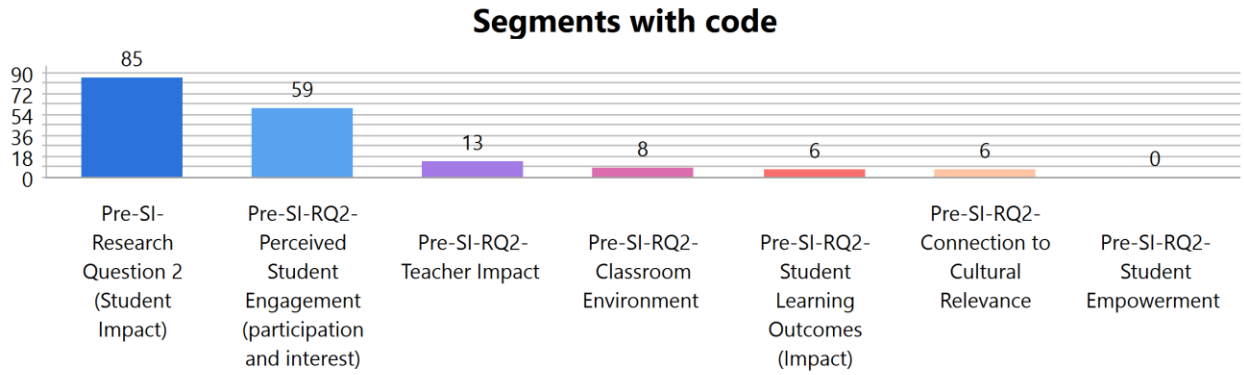
Lesson reflections described culturally connected tasks and interactive activities as central to CRMT lessons. These tasks allowed students to connect mathematics to personal and cultural experiences, making the content feel relevant and engaging.

**Findings for Research Question 2: Student Perceptions of CRMT**

This section presents findings on students' perspectives regarding the impact of CRMT in a high school geometry class. Drawing primarily from post-CRMT student interviews and lesson reflections, the study describes experiences with mathematics during lessons that incorporated identity-affirming, culturally responsive, and students' voices and agency. Research Question 1 focused on when and how engagement occurred during CRMT lessons, and Research Question 2 focuses on student perceptions of instructional changes and their reported influence on confidence, learning, and classroom participation. Students mentioned culturally responsive strategies, including real-world connections, and opportunities for voice and choice. They also described experiences related to motivation, connections to mathematics, and confidence in their ability to succeed.

***Figure 20.***

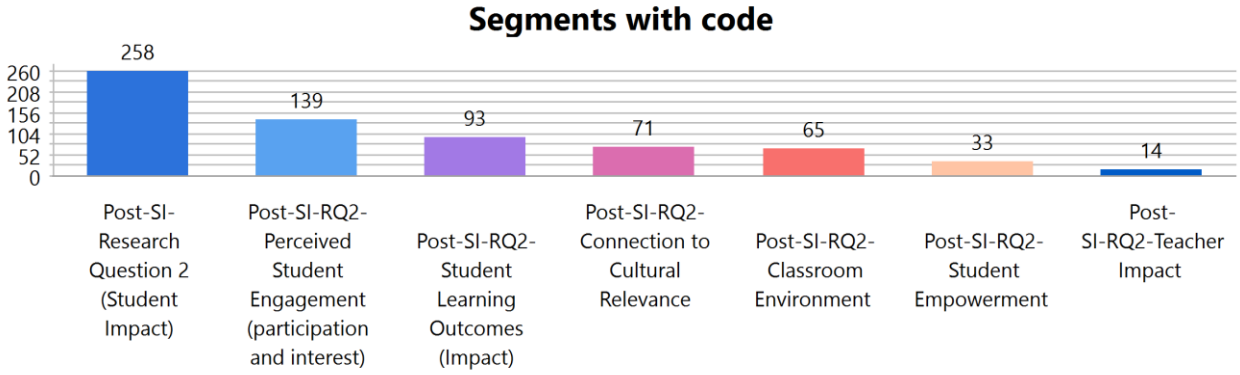
*Graph Representing RQ2 From the Student Interview From the Pre-CRMT Lessons*




*Note.* Figure created by the author.

***Figure 21.***

*Graph Representing RQ2 From the Student Interview From the Post-CRMT Lessons*




*Note.* Figure created by the author.

Figures 13 and 14 show the distribution of students' responses in pre- and post-CRMT student interviews. Before CRMT, students rarely mentioned empowerment, cultural connections, or classroom environment. After implementation, students' responses included references to engagement, learning outcomes, empowerment, and culturally responsive content. Figure 14 illustrates a similar trend in post-lesson reflections, where students describe changes in their understanding, confidence, and sense of belonging.

Students described CRMT lessons as “fun” and “interactive” and used terms such as “inclusive” and “relevant.” The sections that follow present each theme with examples from student interviews, lesson reflections, and classroom activities. In post-CRMT lesson reflections, students referenced engagement, empowerment, and cultural relevance.

***Theme 1: “It Actually Made Sense to Me”:*** This theme describes student reports of deeper understanding, greater confidence, and a sense of belonging in the classroom during CRMT instruction. Students mentioned supportive instruction and opportunities for hands-on learning. Both interview and reflection data included statements about capability, motivation, and inclusion during CRMT. Students described real-world connections and engaged in hands-on exploration, making sense of problems, reasoning through abstract ideas, and modeling mathematical concepts. In student interviews and lesson reflections, students also described a clearer understanding and confidence in connection with these activities.

***Student Interviews:*** In the post-CRMT student interviews (see Figure 14), students described feeling successful and confident in mathematics. Participants described feelings of empowerment and mentioned aspects such as motivation, understanding, and other elements related to their learning.

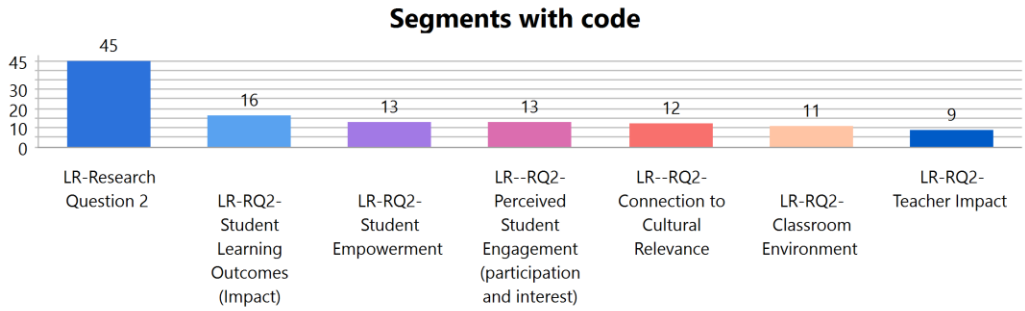
Sam shared:

> Before, I did not really think I was good at math, and it was always just like, here is a formula, memorize it. But now I feel like I can actually do it because I saw how it works. That made it stick more. I understood it better because we were doing it, not just looking at numbers on the board
>
> (Sam, interview, fall 2024)

Other students described how lessons that involved exploration and multiple explanations helped them make sense of mathematics. Raj stated, “We got to figure things out ourselves instead of just being told what to do.” Stella added, “I paid more attention because the lessons were interesting, not only numbers on a page.” These statements described opportunities for exploration, provided pertinent examples, and connected mathematics to students’ lives.

***Figure 22.***

*Graph Representing RQ2 From the Lesson Reflections From the Post-CRMT Lessons*




*Note.* Figure created by the author.

***Lesson Reflections:*** Across both student interviews and lesson reflections, lessons with multiple strategies and active participation were consistently linked to student comments about understanding and confidence. Lesson reflections on activities such as the Play-Doh Composite Shapes and Parallel City projects, as shown in Figure 15, often described students' understanding and confidence.

Students reported that the teacher provided clear explanations, real-world examples, and multiple methods for solving problems. Lesson reflections noted that students engaged with tangible materials before starting group problem-solving tasks. Lucy stated:

> I understood it better because I was doing it, not only listening. It was easier to remember how to find volume because we measured and worked with real objects, instead of just using formulas. Seeing it and touching it helped make math sense to me (Lucy, interview, fall 2024).

Raj stated, *"*Mrs. K made sure we understood by showing us different ways to solve problems, not just one method.*"* Students stated that they were able to ask questions, try different approaches, and work through problems at their own pace.

***Theme 2: "We Figured It Out Together":*** This theme includes student comments and lesson reflections that describe learning through collaboration and peer support during CRMT geometry lessons. Students discussed working together, sharing strategies, and helping one another with problems. Lesson reflections recorded observations of students participating in group activities, discussing their ideas, and checking each other's work. Students described collaborative learning and shared reasoning, referencing activities such as constructing arguments, critiquing peers' reasoning, and making sense of problems.

***Student Interviews:*** In post-CRMT student interviews, students described working with peers as part of their understanding of mathematical concepts and their participation in class activities.

Sam shared:

> It helped me understand better when we worked together. Like, if I did not get something, someone in the group might explain it differently, and then it made sense. Sometimes we argued about the answers, but that actually helped because we had to prove it to each other. And the teacher let us figure it out before stepping in. That made me feel like I could actually think for myself

(Sam, interview, fall 2024).

Lucy explained:

> Working in groups helped me learn because you get to hear what other people are thinking. Sometimes, they explain it in a way that just clicks. We did not copy answers; we actually talked about how to solve them, and that helped
>
> (Lucy, interview, fall 2024)

Students commented on the classroom atmosphere during CRMT lessons. Sam said, "It was different from my last class because everyone was involved, and we helped each other," while Hailey remarked, "I felt more comfortable asking questions because we worked together a lot." Students reported enjoying lessons that incorporated hands-on group work and interactive tasks. Nancy stated, "It was more fun to do activities instead of just listening to the teacher talk," and Hailey added, "I liked it because we got to work together, which made me more interested in the lesson."

***Lesson Reflections:*** Described instances of peer collaboration and group discussions. In lesson reflections, I noted students communicating with one another and explaining their reasoning:

> Students were encouraged to communicate with peers and substantiate each other's calculations, which promoted discussion and engagement. They checked one another's work and clarified misunderstandings through conversation, showing how collaborative norms helped deepen conceptual understanding.

In another reflection, I wrote about how group work:

> I observed that group work encouraged students to share their ideas more openly. Students explained steps to their peers, which led to meaningful discussions about

multiple solution strategies. These interactions showed how students relied on each other for support and reasoning, rather than depending solely on me for answers.

Lesson reflections described discussion and sense-making when students explored tasks before receiving step-by-step instructions:

> Students seemed more invested when they were allowed to figure out solutions to the problems before I explained the procedure. Peer conversations during these moments showed that they were assessing ideas and checking answers together to find a reasonable explanation for the solution.

Challenges with collaboration appeared when group roles were unclear:

> Students who needed more support were in groups with higher-performing peers, which made them hesitant to contribute. This showed me that group roles and task structures needed to be more explicit so that everyone could participate confidently.

Other lesson reflections noted moments of disengagement connected to group dynamics. One entry described a student working in a group without clear roles and responsibilities. Another noted that students struggled to begin the task when guidance was limited and that conversations sometimes shifted off topic. Lesson reflections described group work in lessons with a clear structure. Across student interviews and lesson reflections, students mentioned collaboration, peer explanation, and group problem-solving as key aspects of CRMT-based lessons.

***Theme 3: "I Felt Like I Could Do It":*** This theme presents students' descriptions of confidence and capability in mathematics learning during instruction that involved student choice, independent thinking, and flexible problem-solving. Students described lessons as opportunities to make decisions, explore multiple approaches, and express their ideas. Sam stated, "I felt like I could do it," when describing taking risks, engaging with the content, and

building confidence in mathematical abilities. Students also described making choices and solving problems independently through activities that involved making sense of problems, reasoning abstractly, and using appropriate tools strategically.

**Student Interviews:** Student empowerment did not appear in the pre-CRMT student interviews but was present in post-CRMT responses. Students described opportunities to solve problems independently, make decisions during tasks, and assess their thinking before seeking guidance from the teacher. Lucy explained:

> Usually in math class, the teacher shows us how to do it, and we copy. But this time, we tried it on our own first. Like with the pyramid volume, we got to measure and see if it made sense. I did not feel dumb asking questions because everyone was doing different things. I liked that I could solve it my way, and it still worked
>
> (Lucy, interview, fall 2024).

Students described that prior to showing the procedure before solving, they felt confident asking questions during these activities. Another student shared a similar experience of having time to figure things out independently:

> I liked how the teacher gave us time to figure stuff out. We were not told what to do. Like with the shapes, we created our own and measured everything ourselves. That made me feel like, okay, I got this, I am actually doing it
>
> (Hailey, interview fall 2024).

Stella described creating their own geometric shapes and measuring them, saying it felt like they were actively doing mathematics rather than simply following steps. Other students also mentioned making decisions and trying out their approaches. Across data sources, students

described lessons that included independent thinking, flexible problem-solving, and decision-making.

***Theme 4: "It Was Actually Interesting":*** Students described mathematics lessons that included real-world applications and culturally responsive materials. Students described tasks that reflected their lived experiences or familiar contexts. Comments in student interviews and lesson reflections described relatable content, understanding, participation, and enjoyment.

***Student Interviews:*** In post-CRMT student interviews, students mentioned using real-life objects and examples in mathematics lessons. They also described lessons connected to their own experiences and used terms such as "engaging" and "understandable" to characterize these lessons. Lucy reflected:

> I never thought about math being part of my life, like with cereal boxes or measuring things I see at home. But when we used stuff I know, it was easier to understand. It was not only numbers, it was real
>
> (Lucy, interview, fall 2024).

Stella shared, "Seeing examples from my own culture in class made me feel like math wasn't just about numbers, it relates to real life." Students also used terms such as "memorable" and "meaningful" when describing these types of examples. Angel explained, "I liked how we used real-life examples because it made math make more sense," while Nancy stated, "I paid more attention because the lessons were interesting, instead of numbers on a page."

Students described mathematics lessons that referenced their cultural backgrounds and everyday contexts. They mentioned noticing connections between the lesson content and their own experiences, such as familiar objects, daily-life situations, or examples from their communities. In their accounts, students referred to these lessons as engaging and

understandable. They pointed out specific activities or materials that related to what they already knew or encountered outside of school.

***Lesson Reflections:*** Lesson reflections frequently described the use of familiar objects and real-world contexts in lessons. In my lesson reflection entries, students were noted working with objects they recognized from home or community settings, for example, one reflection described using food containers and household packaging during a lesson on volume.

Lesson reflections noted students using familiar objects such as food containers to measure dimensions, manipulate shapes, and apply geometric procedures. Lesson reflection entries noted students discussing dimensions, checking calculations with peers, and referring to prior experiences. In other reflections, students wrote about using real-world contexts and described how they remembered and applied mathematical procedures in these lessons. Lesson reflections mentioned recalling mathematical procedures after working with tangible materials.

Lesson reflections described students asking for clarification at the start of the activity. Once the task was understood, entries recorded participation from more students and noted their willingness to attempt the problems. In student interviews and lesson reflections, students described their engagement, confidence, and participation in lessons as connected to their experiences, using examples they recognized from their own lives. Students consistently connected their engagement to culturally familiar materials and real-world contexts.

**Summary of Findings**

This chapter presents findings on how CRMT shaped instruction and student experiences in a high school geometry classroom, based on student interviews, teacher lesson reflections, and classroom observations. For Research Question 1, which examined how CRMT influenced student engagement, students described participating in lessons that incorporated group work,

hands-on tasks, and mathematical problems connected to familiar or cultural contexts. Several of the SMPs were recorded in these CRMT lessons. SMP 1 emerged when students worked through problems that required perseverance and reasoning. SMP 4 was evident in the use of physical and real-world objects during mathematical tasks. SMPs 5 and 6 were observed when students used rulers, calculators, and other tools to make measurements and calculations. Student interviews and lesson reflections described instructional routines that included collaboration, concrete examples, and guided support. A smaller number of students mentioned difficulty following directions or completing tasks when instructions were unclear.

For Research Question 2, which explored students' descriptions of their experiences with CRMT instruction, students referenced teacher support, including flexibility, checks for understanding, and examples from their communities or experiences. Classroom interactions were described as collaborative, with students sharing ideas and working in small groups. Students also mentioned independent thinking, including trying different approaches, working at their own pace, and engaging with mathematics through hands-on exploration. Lesson recall was described for tasks that involved real-world or cultural materials, with students referring to objects or examples from their everyday lives. Students noted cultural connections, familiarity with lesson contexts, and comfort participating in CRMT lessons.

Overall, the findings reflect a range of student experiences during CRMT-based geometry instruction as reported through multiple data sources. The next chapter discusses these findings in relation to existing research and explores their implications for culturally responsive mathematics practice.

# CHAPTER 5 DISCUSSION, CONTRIBUTIONS, AND RECOMMENDATIONS

This chapter discusses the findings presented in Chapter 4 and situates them within the existing research and theoretical frameworks. The purpose of this chapter is to analyze and interpret the findings presented in Chapter 4. The discussion is structured around the study's two research questions and links the results to existing literature on CRMT and the SMPs. The findings demonstrate how CRMT transformed student engagement, participation, and confidence by showing how culturally responsive practices supported rigorous and meaningful learning. This work took place in a district responding to post-pandemic declines in motivation and participation, where increasing CDL engagement and advancing STEM readiness were key priorities. In this context, CRMT created learning environments where students felt seen, supported, and included. This study implemented instructional shifts intentionally designed to reflect student diversity, ensure equitable access to rigorous mathematics content, and foster inclusive practices that affirmed students' identities and lived experiences. Instructional decisions were guided by the CRMT framework, as described by Bonner and Adams (2012), which emphasizes high expectations, cultural identity, and student-centered engagement as critical components of effective mathematics teaching. This framework builds on the foundational work of Gay (2010, 2013) on culturally responsive instruction. The SMPs provided an additional structure for examining how students engaged in mathematical reasoning, modeling, and collaborative problem-solving.

The primary data sources for this study were student interviews and lesson reflections, with classroom observations and artifacts serving as secondary evidence to support and corroborate findings. Chapter 4 presented two sets of results: four themes describing student engagement during CRMT instruction (Research Question 1) and four themes reflecting

students' perceptions of learning and empowerment in a CRMT-based classroom (Research Question 2). Building on these findings, this chapter addresses the following research questions:

1. How did CRMT-based instruction influence student engagement in a high school geometry class?
2. How did students perceive the impact of CRMT strategies on their engagement, confidence, and learning in geometry?

CRMT lessons that affirmed student identities, connected mathematics to real-world experiences, and upheld high expectations fostered participation, confidence, and a sense of belonging. These practices positioned students as capable mathematics learners. Synthesizing insights across both research questions, four consistent patterns emerged: (a) real-world and familiar contexts increased engagement, (b) hands-on and collaborative tasks deepened participation, (c) opportunities for choice fostered ownership, and (d) supportive relationships encouraged academic risk-taking.

While Fredricks et al.'s (2004) tripartite model provided an essential lens for recognizing behavioral, emotional, and cognitive aspects of engagement, the integration of CRMT practices and the SMPs allowed for a fuller picture of how engagement was experienced and expressed in this classroom.

**Discussion of Findings for Research Question 1: Impact of CRMT on Student Engagement**

***Theme 1: Hands-On Activities and Group Work:*** Lesson reflections and artifacts showed that hands-on, culturally meaningful modeling impacted how students engaged with mathematics, with classroom artifacts providing additional support for these insights. CRMT-based lessons deliberately used real-world objects, such as coconuts, bread, sports balls, tissue boxes, and cans, which students recognized from their homes and communities. By physically

constructing and measuring shapes, students could see, touch, and manipulate the mathematics they were learning, turning abstract formulas into concepts that felt relevant and understandable. These teaching strategies embody CRMT principles of honoring students' cultural knowledge while maintaining rigorous, standards-based content (Bonner & Adams, 2012; Gay, 2010; Ladson-Billings, 1995).

The challenge of calculating volumes with and without the white portion of the coconut illustrated how students persevered through complex problems. Instead of adding new reflections, these findings can be understood considering CRMT literature that emphasizes perseverance, problem-solving, and reasoning as culturally responsive practices. Aguirre and Zavala (2013) highlight that CRMT tasks promote agency by allowing students to explore authentic contexts, while Hammond (2015) notes that scaffolding such tasks supports students in managing cognitive demand. This aligns with how students in this study engaged in collaborative reasoning and modeled with mathematics in ways that deepened their understanding.

These findings align with CRMT research showing that mathematics becomes more accessible and meaningful when instruction draws on students' cultural knowledge and everyday experiences (Gay, 2010, 2013; Ladson-Billings, 1995). Tran et al. (2022) and Suh and Calabrese (2025) found that culturally responsive, interactive lessons improve persistence and conceptual understanding, while Harris et al. (2023) and Mamedova and Orosco (2024) reported that such tasks strengthen students' agency, confidence, and participation. Consistent with CRMT literature, students demonstrated that their cultural backgrounds shaped not only their experiences but also their natural ways of approaching mathematical problems. Their preferred strategies, organizational methods, and reasoning patterns functioned as cultural resources that supported engagement.

Overall, lesson reflections and artifacts demonstrated that hands-on modeling using culturally familiar objects extended beyond participation by deepening conceptual understanding, validating students' experiences, and positioning them as capable problem solvers whose cultural knowledge was recognized as valuable in mathematics learning. Together, these findings illustrate how CRMT strategies that integrate familiar objects and hands-on modeling not only increase engagement but also provide students with meaningful entry points into abstract mathematics. This theme emphasizes the value of connecting content to cultural and everyday knowledge as a pathway to rigorous participation, setting the stage for how collaboration and choice further shape engagement in subsequent lessons.

***Theme 2: Choice-Making and Collaboration****:* Lesson reflections revealed that opportunities for meaningful choice and collaboration fostered engagement by affirming students' cultural identities and increasing ownership of learning. CRMT-based instruction transformed the classroom from a teacher-centered environment to one where students exercised agency, making decisions about materials, strategies, and cultural connections. These practices reflect core CRMT principles of student voice, cultural relevance, and shared responsibility for learning (Bonner & Adams, 2012; Gay, 2010; Ladson-Billings, 1995).

Students described how having choices in their tasks reduced anxiety and made learning more meaningful. For example, working with familiar household items helped them see geometry as relevant to their lives, beyond abstract formulas. This finding aligns with research highlighting that when students can make authentic choices, their cultural identities are validated, and they are positioned as active contributors to the learning process (Gay, 2010, 2013; Ladson-Billings, 1995). Hammond (2015) further explains that scaffolding decision-making builds autonomy and confidence, which mirrors how students in this study gained ownership of their

work when offered flexibility and support. Collaboration was equally important for sustaining engagement. Students noted that working with peers allowed them to share strategies, verify solutions, and clarify misunderstandings, which strengthened both reasoning and persistence. These experiences align with CRMT literature identifying collaboration as essential for fostering discourse, reasoning, and shared ownership of learning (Aguirre & Zavala, 2013). More recent studies also emphasize that culturally connected group work improves persistence and motivation (Suh & Calabrese, 2025; Tran et al., 2022) and builds confidence through belonging and peer support (Harris et al., 2023).

When choice and collaboration were combined, as in culturally relevant projects like the Parallel City Poster, students connected mathematics to their cultural identities while exercising creativity and autonomy. These projects demonstrated that rigorous content and cultural affirmation can coexist, enabling students to engage in geometric reasoning while incorporating meaningful cultural references. This outcome reflects the broader CRMT framework, which views cultural knowledge as an academic asset and positions students as co-creators of knowledge (Bonner & Adams, 2012; Ladson-Billings, 1995).

Overall, lesson reflections and student interviews, with artifacts providing secondary support, demonstrated that culturally meaningful choice and intentional collaboration fostered engagement both cognitively and socially. CRMT practices that center on student voice and collaborative learning fostered students' ownership of their learning, building confidence and preparing them for deeper participation in subsequent lessons.

***Theme 3: Connection, Confidence, and Participation****:* Findings from lesson reflections revealed that incorporating real-world, culturally familiar objects into lessons enabled students to build confidence, participate more actively, and perceive mathematics as a meaningful subject.

By validating students' experiences with items from home or their communities, instruction fostered motivation and helped them view themselves as capable mathematics learners (Gay, 2010; Ladson-Billings, 1995).

Students' reflections showed that measuring everyday household objects, such as cereal boxes and food containers, helped them connect geometric formulas to contexts they recognized from daily life. This process made mathematics feel less abstract and more relevant, reinforcing the CRMT principle that cultural familiarity can provide accessible entry points into rigorous content. These activities also aligned with SMP 1 (Make sense of problems and persevere in solving them) and SMP 4 (Model with mathematics), as students applied measurement skills in authentic problem-solving contexts.

These reflections illustrate how familiar objects helped students bridge procedural work with meaningful applications. Students who had previously viewed mathematics as a set of rules and formulas began to see it as relevant to daily life. These activities aligned with SMP 1 (Make sense of problems and persevere in solving them) and SMP 4 (Model with mathematics), as students engaged in hands-on measurement tasks that connected directly to abstract content.

Collaboration also played a role in building confidence and encouraging participation. As students compared results with peers, they engaged in discussions about discrepancies, which required them to articulate reasoning and evaluate alternative strategies. These collaborative exchanges fostered accountability while reflecting SMP 3 (Construct viable arguments and critique the reasoning of others). CRMT literature affirms this finding, noting that discourse and peer interaction are powerful tools for deepening engagement and conceptual understanding (Aguirre & Zavala, 2013).

Reflections also highlighted the need for explicit scaffolding to ensure equitable participation. For example, some students require additional guidance with calculator functions to handle exponents and use the pi key effectively. This finding underscores Hammond's (2015) assertion that scaffolding is critical in helping students manage cognitively demanding tasks. Providing technical support alongside culturally meaningful instruction is therefore necessary for students to engage fully and confidently. These findings align with CRMT scholarship showing that instruction connected to students' cultural experiences strengthens engagement and understanding (Gay, 2010, 2013; Ladson-Billings, 1995). Aguirre and Zavala (2013) emphasize that contextualized tasks build reasoning and agency, while Hammond (2015) explains that scaffolding enhances learners' ability to engage with challenging content. Recent studies further affirm these principles: Tran et al. (2022) and Suh and Calabrese (2025) found that culturally meaningful, interactive lessons improve persistence and conceptual understanding, and Harris et al. (2023) and Mamedova and Orosco (2024) demonstrated that such strategies enhance confidence, agency, and belonging in mathematics.

Overall, lesson reflections demonstrated that when students engaged with culturally meaningful, real-world objects and received appropriate support, they became more confident, active participants in mathematics. These CRMT strategies, affirming identity, connecting content to lived experiences, and maintaining rigor, transformed learning from abstract and intimidating to relevant, empowering, and inclusive.

***Theme 4: Real-World Relevance:*** Findings from lesson reflections and student interviews showed that real-world and culturally familiar contexts supported student engagement by making mathematics feel meaningful and applicable. Students described how working with objects such as cereal boxes, coconuts, and food containers helped them connect abstract

formulas to experiences from their daily lives. These activities demonstrated how CRMT strategies that draw from students' lived experiences create accessible entry points to rigorous content while affirming cultural knowledge (Gay, 2010; Ladson-Billings, 1995).

The importance of relevance is emphasized in CRMT scholarship, which highlights that situating mathematics in meaningful contexts increases both engagement and persistence. Aguirre and Zavala (2013) explain that authentic, contextualized tasks promote reasoning and agency, while Hammond (2015) notes that familiar problems reduce affective barriers and build confidence in approaching challenging work. The findings from this study align with these perspectives, showing that when instruction was connected to students' lives, they participated more actively and demonstrated greater perseverance.

Real-world tasks also engaged students in several Standards for Mathematical Practice. Students modeled with mathematics (SMP 4) when translating objects into geometric representations and performing calculations, and they reasoned abstractly and quantitatively (SMP 2) as they moved between measurements and formulas. These practices demonstrate how CRMT strategies that prioritize relevance can promote both engagement and rigorous mathematical reasoning.

**Discussion of Findings for Research Question 2: Student views and voices on the Impact of CRMT on Student Engagement**

***Theme 1: "It Actually Made Sense to Me":*** Students explained that CRMT-based instruction helped them better understand mathematics and increased their confidence, motivation, and sense of belonging. Many noted that before the CRMT lessons, mathematics felt disconnected and procedural, with an emphasis on memorizing formulas rather than understanding concepts. With CRMT-aligned instruction, they began to see mathematics as

tangible and relevant to their lives. Students explained that choice-making and the use of familiar materials helped them feel capable of doing mathematics, shifting their perceptions from "not good at math" to confident learners.

Students frequently emphasized that interactive, real-world activities made mathematics easier to understand and more enjoyable, helping them persist. These experiences reflected SMP 4 (Model with mathematics) and SMP 1 (Make sense of problems and persevere in solving them), as students described connecting formulas to real-life examples and persisting through tasks that had previously felt abstract. They valued opportunities to explore and solve problems in ways that felt relevant to their own lives, describing the lessons as "more interesting" and "easier to understand." These experiences fostered a sense of autonomy and self-efficacy as students began to see themselves as capable mathematics learners.

Students' descriptions reflect the principles of CRMT, which emphasize building on learners' cultural knowledge and lived experiences to support academic success (Gay, 2010; Ladson-Billings, 1995). Working with tangible, familiar objects aligned with research showing that contextualized mathematics instruction promotes deeper understanding and engagement (Acharya et al., 2021; Aguirre et al., 2013). Recent studies support these findings. Tran et al. (2022) and Suh and Calabrese (2025) found that meaningful, relevant instruction improves persistence and conceptual understanding, while Harris et al. (2023) and Mamedova and Orosco (2024) emphasized the importance of affirming students' identities and experiences in mathematics. Banks (2015) and Nieto (2000) similarly argue that instruction that validates students' identities builds both confidence and a sense of belonging, which mirrors how students in this study described feeling more capable and connected during CRMT lessons.

Hammond's (2015) concept of "cognitive scaffolding" further supports these findings. Students appreciated step-by-step modeling, varied explanations, and visual tools that reduced confusion and made mathematics more accessible. By combining culturally responsive content with scaffolded instruction, CRMT positioned students as active sense-makers, aligning with Aguirre and colleagues' (2013) call for teaching practices that foster reasoning and agency.

Overall, students perceived CRMT instruction as transformative. They associated these lessons with increased confidence, deeper comprehension, and a stronger sense of ownership over their learning. Many contrasted their CRMT experiences with traditional instruction, which had felt distant and procedural, explaining that these lessons helped shift their perceptions of mathematics from alienating to accessible and from intimidating to empowering.

***Theme 2: "We Figured It Out Together":*** Students explained that collaboration and peer interaction enhanced their learning, confidence, and engagement in CRMT-based geometry lessons. In interviews, students frequently emphasized the value of working with peers, sharing strategies, and jointly exploring mathematical ideas. Their reflections revealed that group work helped them better understand content and feel a stronger sense of connection to their classroom community. Students reflected that working through disagreements with peers supported confidence and reinforced understanding, as they learned by explaining and justifying ideas to one another. This type of discourse aligns with SMP 3 (Construct viable arguments and critique the reasoning of others), as students engaged in collaborative reasoning and justified their solutions to peers. Many students explained that peer explanations often felt more relatable and easier to understand than those from teachers.

Collaborative projects, such as the Parallel City Poster, illustrated how students applied content knowledge while engaging in shared decision-making, which affirmed both their

mathematical competence and personal contributions. Students' accounts align with Gay's (2000, 2010) vision of culturally responsive classrooms as communities that value interdependence and collective growth. Ladson-Billings (1995, 2009) similarly emphasized "collective responsibility for learning," a principle evident in how students described co-constructing knowledge with their peers. Aguirre and Zavala (2013) also identified collaboration as a key CRMT practice that encourages shared inquiry and discourse. More recent studies support these findings. Tran et al. (2022) and Suh and Calabrese (2025) found that collaborative, contextualized mathematics activities enhance engagement and persistence. Meanwhile, Harris et al. (2023) highlighted the role of peer discourse in building a sense of belonging and confidence. Acharya et al. (2021) and Banks (2015) further demonstrated that when students are positioned as active contributors to problem-solving, they develop stronger reasoning and more positive academic identities.

Overall, students viewed collaboration as more than a classroom activity. They saw it as a meaningful way to learn mathematics, build confidence, and feel part of a supportive community. Opportunities to 'figure it out together' helped them see themselves as contributors to the learning process and strengthened their confidence in succeeding in mathematics.

***Theme 3: "I Felt Like I Could Do It": This*** theme highlights how CRMT-based instruction, which emphasizes culturally meaningful tasks and student agency, fosters empowerment and confidence among culturally diverse learners. Students described feeling more confident when they were encouraged to explore, make choices, and try multiple approaches to solving problems. Moving from teacher-directed instruction to student-led discovery gave students greater ownership of learning and reduced anxiety, particularly for those who had felt disengaged or intimidated by mathematics. Students noted that creating their own

mathematical models increased ownership and comprehension, making learning feel authentic rather than procedural. Students valued having choices in how they approached mathematical tasks. They also explained that having multiple approaches available reduced anxiety and increased willingness to persist with challenging tasks.

Lesson reflections reinforced these perceptions, noting that tasks such as building composite shapes or applying formulas to household objects gave students a sense of agency and reinforced the relevance of mathematics. The empowerment students described reflects Hammond's (2015) assertion that culturally responsive instruction builds independence by challenging students within their zone of proximal development while providing appropriate scaffolds for success. Ladson-Billings (1995, 2009) similarly emphasized that CRMT positions students as active participants responsible for their learning, and Aguirre and Zavala (2013) identify agency, identity, and authority as central to CRMT.

Recent studies have reinforced these ideas. Tran et al. (2022) and Suh and Calabrese (2025) found culturally meaningful tasks, which provide opportunities for choice and exploration, strengthen persistence and conceptual understanding. Harris et al. (2023) and Stinson et al. (2023) demonstrated that CRMT strategies emphasizing student voice and agency improve students' sense of competence and belonging. Mamedova and Orosco (2024) demonstrated that empowerment increases when students participate in tasks that reflect their cultural knowledge and lived experiences.

Overall, empowerment emerged not only from encouragement but also from instructional designs that centered on students' voices, choices, and reasoning. CRMT practices that fostered ownership and active participation helped students view themselves as confident and capable

mathematicians, challenging deficit-based assumptions that often constrain culturally diverse learners.

***Theme 4: "It Was Actually Interesting":*** This theme captures how students responded to CRMT lessons that intentionally incorporated real-world applications and culturally familiar materials. Across interviews and reflections, students consistently shared that mathematics felt more engaging, relevant, and enjoyable when tasks were connected to their daily lives, communities, and experiences. Instead of viewing mathematics as abstract or disconnected, students described how CRMT strategies made the subject meaningful and valuable, which increased both motivation and understanding. Students frequently described how connecting mathematics to familiar contexts, such as household objects, shifted their view of the subject from abstract to practical and relevant. Students appreciated lessons that reflected context familiar to them, as this gave their learning a sense of purpose. They emphasized that these lessons felt useful and connected to real life, which increased their motivation and attention.

These experiences reflect SMP 4 (Model with mathematics), as students applied geometric concepts to familiar contexts, making abstract formulas more meaningful. Several students shared that having examples from their own lives or cultures not only improved their understanding but also made mathematics feel welcoming and relevant to who they are. As Stella explained, *"*Seeing examples from my own culture in class made me feel like math was not just about numbers; it relates to real life.*"*

Lesson reflections echoed these perceptions, showing that working with familiar household items helped students remember content and view mathematics as meaningful. These findings align with CRMT literature, which emphasizes the importance of affirming students' cultural identities while supporting academic growth. Gay (2010, 2013) and Ladson-Billings

(1995) highlight that CRT validates students' lived experiences, making learning more meaningful. More recent research supports this finding as well. Tran et al. (2022) and Suh and Calabrese (2025) found that culturally responsive, real-world approaches increase engagement and persistence in mathematics. Additionally, Mamedova and Orosco (2024) demonstrated that affirming students' cultural and linguistic knowledge improves participation and learning outcomes.

Overall, students described feeling more invested in mathematics when lessons connected to their lives and cultures. They were more willing to participate, ask questions, and retain what they learned when the content felt authentic and valuable. CRMT approaches that draw on familiar contexts did not reduce rigor but reframed it in ways that were meaningful and affirming. When students described mathematics as 'actually interesting,' they expressed a shift in how they viewed both the subject and their roles as capable learners.

**Synthesis Across Both Research Questions**

Findings from both research questions revealed overlapping patterns in how CRMT influenced engagement, empowerment, and learning in a high school geometry classroom. Whether examining engagement during instruction (RQ1) or students' reflections on CRMT's impact (RQ2), several themes consistently emerged: hands-on and collaborative learning, real-world and culturally responsive content, supportive classroom relationships, and student-centered strategies. Taken together, the results indicate that CRMT promotes behavioral, cognitive, and emotional engagement, aligning with the CRMT framework (Bonner & Adams, 2012) and the SMPs.

Table 2 provides a comparison of the themes identified for each research question, highlighting both the overlap and the unique ways in which CRMT shaped students' engagement during instruction and their perceptions of mathematics learning.

Table 2

*Comparison of Themes Identified for Each Research Question*

| **Research Question 1 Themes (During CRMT Instruction)** | **Research Question 2 Themes (Student Perceptions)** |
|---|---|
| **Theme 1: Hands-On Activities and Group Work** – Students engaged deeply when working with tactile models, real objects, and collaborative tasks that connected mathematics to familiar experiences. | **Theme 1: "It Actually Made Sense to Me"** (Clarity and Confidence) – Students felt mathematics became clearer and more meaningful with CRMT lessons that were interactive, responsive, and confidence-building. |
| **Theme 2: Choice-Making and Collaboration** – Opportunities for decision-making in culturally familiar contexts supported student agency, voice, and reasoning through peer interaction. | **Theme 2: "We Figured It Out Together"** (Collaboration and Peer Learning) – Students valued peer collaboration, shared problem-solving, and learning from one another in ways that felt supportive and empowering. |
| **Theme 3: Connection, Confidence, and Participation** – Real-life contexts and scaffolded support helped students participate actively, build confidence, and connect mathematics to their lives. | **Theme 3: "I Felt Like I Could Do It"** (Empowerment and Agency) – CRMT empowered students by providing meaningful choices, multiple strategies, and opportunities to see themselves as capable mathematics learners. |
| **Theme 4: Supportive Relationships and Classroom Climate** – Affirming relationships and a respectful climate encouraged students to take risks, ask for help, and engage more fully in mathematics. | **Theme 4: "It Was Actually Interesting"** (Relevance and Engagement) – Students found lessons engaging and motivating when content reflected real-world and cultural relevance. |

Across lesson reflections and student interviews, students consistently described mathematics as more engaging and enjoyable when tasks connected to their daily lives, communities, and experiences. Lessons intentionally incorporated community-based examples, culturally familiar objects, and contexts that reflected students' backgrounds. These cultural connections allowed students to see themselves reflected in the content and positioned their

knowledge as a meaningful resource for learning mathematics. Tasks that used everyday objects or community projects helped students connect formulas to meaningful experiences, fostering ownership in problem-solving. Students also valued collaborative work on culturally responsive tasks, noting that discussion and peer interaction supported reasoning and affirmed cultural perspectives. This aligns with Bonner and Adams' (2012) emphasis on instructional engagement, cultural identity, and relational support as core dimensions of CRMT.

Overall, heightened motivation and participation were tied less to hands-on work alone and more to instruction that felt inclusive and identity-affirming. This aligns with Gay (2010, 2013) and Ladson-Billings (1995) on validating students' identities to foster confidence and belonging, and with recent findings that contextualized mathematics enhances agency and participation (Harris et al., 2023; Mamedova & Orosco, 2024; Suh & Calabrese, 2025). Using a multidimensional view of engagement, behavioral, cognitive, and emotional, the study found that culturally responsive practices influenced each domain by affirming students' identities, connecting mathematics to lived experiences, and fostering agency. Behavioral engagement increased as culturally familiar tasks drew students into active participation; cognitive engagement grew as exploration and reflection anchored concepts in experience; and emotional engagement expanded as students felt respected and affirmed, shifting perceptions of mathematics toward belonging.

These outcomes reflect Hammond's (2015) view that culturally responsive pedagogy reduces threat and builds trust to activate learning and affirm Bonner and Adams' (2012) model, emphasizing cultural identity, instructional engagement, relationships, and reflection. Here, engagement was not a byproduct of activities alone but of instruction that validated cultural identities while maintaining high expectations.

**Alignment with the CRMT Framework and the SMPs**

Instructional practices aligned with Bonner and Adams' (2012) CRMT model, emphasizing cultural identity, instructional engagement, high expectations, and relational support, by integrating students' involvement, lived experiences, and cultural knowledge into mathematical learning. Lessons were designed to integrate students' lived experiences, community contexts, and cultural knowledge as essential components of mathematical learning. These practices also reflected Aguirre and Zavala's (2013) framework centering equity, cultural relevance, and student agency: students actively constructed meaning, explained reasoning, and applied mathematics in ways connected to their lives. Table 3 summarizes how observed CRMT practices aligned with selected SMPs, with examples from this study.

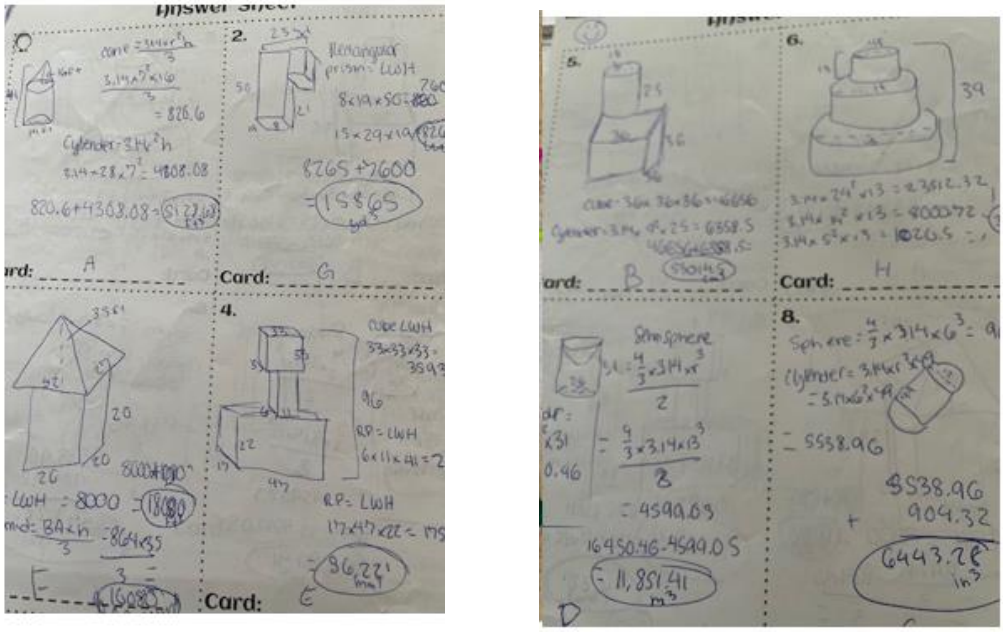
Table 3

*CRMT–SMP Alignment in This Study*

| **CRMT practice (example)** | **Primary SMP(s)** | **How it appeared** |
|---|---|---|
| Culturally familiar, real-world tasks (e.g., household objects, community projects) | SMP 4 (Model with mathematics), SMP 2 (Reason abstractly and quantitatively) | Students translated real contexts into geometric representations and calculations, moving between measures and formulas. |
| Collaborative sense-making and peer discourse | SMP 3 (Construct viable arguments and critique the reasoning of others) | Students justified strategies, compared solutions, and refined reasoning through discussion. |
| Precision within meaningful applications | SMP 6 (Attend to precision) | Students measured carefully, rounded appropriately, and checked calculations tied to authentic tasks. |
| Pattern finding and structure with guided exploration | SMP 7 (Look for and make use of structure) | Students used models/scaffolds to identify relationships among geometric elements. |

***Figure 23.***

*Students applying their understanding to complex problems after the CRMT lesson*



*Note.* Student artifact collected by the author.

Figure 23 depicts students tackling multi-step problems following the CRMT sequence. This alignment between CRMT principles and the SMPs fostered a learning environment that was both culturally affirming and intellectually rigorous. Students were not only engaging in best practices, such as hands-on tasks or collaboration, but they were also participating in mathematics that validated their identities, connected them to their communities, and empowered them to view themselves as capable mathematical thinkers.

**Contributions to Research and Practice**

This study extends CRMT scholarship to the high school geometry context, focusing on culturally diverse learners and the ways they experience engagement through culturally responsive instruction. While much of the existing CRMT research has focused on elementary and middle school mathematics, this study demonstrates that the Bonner and Adams (2012)

framework, rooted in cultural identity, instructional engagement, communication, and reflection, can be meaningfully applied in secondary settings where students work with more abstract and procedural content. Using student interviews and lesson reflections as primary data, supported by classroom artifacts and observations, the study shows that CRMT strategies can foster engagement, confidence, and deeper understanding while maintaining academic rigor in mathematics.

Beyond extending CRMT into a secondary context, this research emphasizes the importance of centering student voice to understand what engagement looks and feels like from their perspective. Many CRMT studies have focused primarily on teacher practices, but fewer explore how students themselves interpret culturally responsive instruction and connect it to their learning experiences. By foregrounding student perspectives, this work provides insight into how trust, collaboration, and task design contribute to engagement in mathematics. The study also demonstrates how integrating CRMT with the SMPs can bridge cultural and disciplinary frameworks, helping students see themselves as capable mathematical thinkers. In doing so, it contributes to a growing body of scholarship that reimagines mathematics learning as both rigorous and humanizing, where cultural relevance and academic excellence work together to support success for all students.

At the same time, these findings hold practical implications for mathematics educators seeking to design instruction that affirms identity, recognizes cultural experience, and invites active student roles to deepen connections to mathematics (Bonner & Adams, 2012; Gay, 2000, 2013). Teachers can apply several key principles derived from this study:

- **Design relevance-first tasks**: Integrate culturally familiar, real-world contexts as core entry points, not as add-ons, to rigorous content, allowing students to connect procedures to lived experiences (Bonner & Adams, 2012; Gay, 2000, 2013).
- **Pair agency with structure:** Build meaningful student choice (materials, strategies, representations) and routinized peer discourse so students exercise voice and practice justifying reasoning (Aguirre & Zavala, 2013).
- **Enact a "warm demander" stance:** Combine relational care with high expectations and targeted scaffolds (e.g., modeling, tools) to reduce anxiety and sustain persistence in cognitively demanding tasks (Hammond, 2015).

Overall, the study reinforces that CRMT is not a checklist of cultural examples but an intentional, relational, and reflective practice. Students emphasized the value of instructional designs that elevate voice, provide meaningful choices, encourage collaboration, and build trust, practices that align with Bonner and Adams' (2012) conception of CRMT as dynamic and ongoing. These results demonstrate that CRMT and rigorous, standards-based instruction are complementary rather than competing aims. With appropriate scaffolds, students engaged productively in geometry topics while developing confidence, agency, and mathematical persistence.

**Implications for Curriculum and Instruction and Professional Development**

The findings show that CRMT can be implemented without reducing rigor when relevance, student agency, collaborative sense-making, and explicit support are intentionally

integrated into the learning process. The implications below transform these results into practical guidance for high school mathematics, while remaining aligned with the SMPs.

***Curriculum and Instruction:*** First, unit design should be centered around relevance. Culturally familiar, real-world contexts should serve as anchors rather than decorative add-ons, enabling students to connect procedures and concepts to lived experiences while meeting standards. A small set of high-impact anchor tasks (e.g., modeling the volume of household items or designing community layouts) can be used to backward-map lessons, practice activities, and culminating tasks. Culminating tasks should clearly elicit SMP 4 (Model with mathematics) and SMP 2 (Reason abstractly and quantitatively), with criteria that focus on modeling choices, assumptions, and justification. Brief openers that tap what students already know, paired with end-of-unit reflections, make the link between relevance and rigor clear.

Second, pair student agency with clear expectations, both for what constitutes success and how students will participate in discussions. Choice boards or strategy menus can be combined with participation frameworks that assign roles, define talk moves, and require justification, thereby supporting SMP 3 (Construct viable arguments and critique the reasoning of others). Begin with accessible tasks, progress to more complex ones, and conclude with a shared summary so exploration turns into formal understanding. Maintain a quick count of who speaks or use a simple discussion tracker. Then, ask each student to provide a brief written explanation or complete an exit ticket to capture their thoughts. This balance of choice and structure reduces anxiety, demonstrates that more than one method can be effective, and fosters deeper understanding.

Third, relevance should be coupled with explicit scaffolding and attention to precision. Because authentic contexts may raise cognitive demand, instruction should include just-in-time

mini-lessons and tool fluency (e.g., calculator routines for exponents and π, unit-conversion protocols) so that students can focus on sense-making. Worked examples that are gradually faded, progressions from concrete to representational to abstract, and accuracy checklists tied to SMP 6 (Attend to precision) can be used to manage cognitive load while maintaining high expectations. Review common mistakes in context (e.g., rounding too early or mixing up units) and offer light language support for multilingual learners (sentence frames, key terms). This shows that cultural relevance and precision can go hand in hand.

***Professional Development:*** First, professional learning should center on practice and include protected time for collaborative planning. Use concrete lesson examples, task banks, and short video clips showing CRMT in geometry to anchor a plan–teach–reflect cycle (e.g., lesson study or coaching). Teams co-plan an anchor task, name specific look-fors (student talk, modeling choices, justification), observe instruction, study student work through an equity lens, and revise materials. Protecting common planning time allows teachers to adapt tasks to local contexts, align criteria with the SMPs, and co-design supports, thereby strengthening implementation and teacher confidence.

Second, professional development should build asset-based perspectives (Gay, 2010; Ladson-Billings, 1995) and a "warm demander" stance that pairs care with high expectations (Hammond, 2015). Use reflection tools to track who speaks, how often, and in what roles, and to note teacher moves that affirm identity, invite student voice, and press for justification. Give brief bursts of feedback that make thinking visible, probe the "why," and provide just enough support to keep the challenge high without raising stress. Over time, these practices help create classrooms where students feel recognized, capable, and responsible for high-quality mathematical work.

**Implementation and Evaluation of Student Engagement**

Implementation aimed at increasing student engagement is best approached incrementally. Departments might begin with one or two pilot units per course and scale based on evidence. Pacing guides, materials budgets, and planning timelines should be aligned so that anchor tasks and formative routines are feasible and supported. Planning documents should name the specific engagement goals for each unit (e.g., increased equitable participation, more frequent justification aligned to the SMPs) and the routines that will support them.

Evaluation should employ a multidimensional view of engagement. Behavioral engagement can be tracked through participation and discourse patterns (e.g., equitable distribution of talk, role rotation, persistence with tasks). Cognitive engagement can be documented in SMP-aligned work samples and revisions that show modeling choices, reasoning, and precision over time. Emotional engagement can be monitored through brief check-ins on belonging, interest, and confidence, as well as short reflective prompts embedded in lessons. Data should be collected at baseline and at key points within and after each unit and then disaggregated to examine equity patterns across student groups. Triangulating these measures supports valid inferences about how CRMT influences engagement.

Continuous improvement cycles help sustain progress. Teacher teams can review participation maps and student work, compare results to the stated engagement goals, and adjust tasks, scaffolds, or discussion routines accordingly. Sharing exemplars and “quick wins” in engagement (e.g., broader distribution of student talk, more substantial written justifications on SMP-aligned observation guides) during department meetings can build collective efficacy and maintain momentum, ensuring that CRMT operates as a coherent approach rather than a one-off initiative.

Implemented with commitment, these moves can transform classroom culture by affirming identity, fostering engagement, and building mathematical confidence while maintaining rigorous expectations. In summary, relevance-first design, structured opportunities for agency, targeted scaffolding with attention to precision, and practice-based professional learning offer a practical pathway to enhancing student engagement in high school mathematics.

**Delimitations of the Study**

This study offers valuable insights into how CRMT strategies impact student engagement in a high school geometry classroom; however, several limitations must be acknowledged to contextualize the findings. These limitations relate to the researcher's role, the intentionally bounded sample, the local context and duration, and the breadth of data sources. As Hiebert et al. (2023) emphasize, it is important to consider how such limitations influence the interpretation and significance of the findings.

First, I served in both teaching and research roles. This dual role provided sustained access and insight but may have influenced participation and responses. To reduce bias, I kept reflexive notes, conducted informal member checking on emerging interpretations when feasible, and triangulated interviews with lesson reflections and artifacts.

The study examined one high school geometry classroom with eight culturally diverse learners. The intentionally bounded sample means that the findings should not be generalized across all high school mathematics classrooms or student populations, given the small sample size of 8 and the single-site design. Students' experiences were shaped by the school's culture, community context, and their prior histories with mathematics. While the small sample allowed for rich and detailed exploration of student voice, it limits the breadth of applicability to other contexts.

The instructional changes were implemented within a single geometry unit in one school. Local factors (e.g., pacing, materials, and classroom routines) may differ elsewhere. Because the study followed students only across a short unit, long-term outcomes and transfer to new mathematical topics remain unknown. Consistent with the study's focus on student voice, data analysis prioritized student interviews and lesson reflections, using artifacts and classroom observations as corroborating evidence rather than systematically coded datasets. This approach aligns with the study's purpose but narrows triangulation relative to qualitative designs that code multiple data streams or engage independent coders.

**Concluding Statement**

This study examined the impact of CRMT on student engagement and learning in a high school geometry class, addressing a gap in existing research that has primarily focused on elementary and middle school levels. Using student interviews and lesson reflections (supported by artifacts and observations), the results show that CRMT is more than just a collection of techniques; it is a framework that affirms students' cultural identities, links mathematics to real-life experiences, and combines high expectations with meaningful support. When teaching reflected students' communities and backgrounds, mathematics shifted from being abstract and disconnected to being responsive, engaging, and empowering.

Across both research questions, a clear picture emerged. Relevance-first tasks helped students see mathematics as valuable and worthwhile; collaborative discussions and peer reasoning supported understanding and a sense of belonging; agency through structured choice reduced anxiety and boosted persistence; and relational trust, combined with high expectations, sustained academic risk-taking. These dynamics activated key SMPs, especially modeling (SMP 4), reasoning abstractly and quantitatively (SMP 2), making sense of problems and persevering

(SMP 1), and constructing and critiquing arguments (SMP 3), showing that cultural responsiveness and rigor are complementary rather than conflicting goals.

The study's implications for curriculum and professional learning are summarized earlier; they emphasize designing relevance-first tasks, fostering structured student voice and discourse, and adopting a "warm demander" approach through targeted scaffolding. Although the conclusions are limited by a small, single-site sample, a teacher–researcher context, and a brief instructional unit, the evidence indicates that CRMT offers a practical pathway to promoting equity and excellence in high school mathematics. When classrooms honor students' cultural knowledge and lived experiences, culturally diverse learners not only participate more actively but also start to see themselves as capable contributors in mathematics. This outlook holds importance for future STEM pathways.

This study affirms that CRMT can serve as both a bridge and a catalyst for equity in secondary mathematics. By grounding instruction in students' lived experiences while maintaining rigorous expectations through the SMPs, CRMT creates learning spaces where CDLs can thrive academically and personally. The findings underscore that engagement, confidence, and persistence grow when mathematics is humanized, when it honors identity, invites voice, and connects to students' worlds. The study's overall contribution lies in demonstrating that equity and excellence are not opposing aims but complementary imperatives that can coexist in every mathematics classroom.

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# APPENDICES

## Appendix A

Parental Consent Form

**Georgia State University**
**Parental Informed Consent**

**Title:** THE IMPACT OF CULTURALLY RESPONSIVE MATHEMATICS TEACHING ON

STUDENT ENGAGEMENT: A CASE STUDY OF A GEOMETRY CLASS

**Principal Investigator:** Dr. Christopher C. Jett

**Student Principal Investigator:** Anu Krishna

**Introduction and Details**
We are asking your child to take part in a research study. It is up to your child to decide if they would like to be in the study. The goal of this study is to see the result of Culturally Responsive Mathematics Teaching (CRMT) on culturally diverse student work in geometry mathematics class. Your child will need to spend about 30 minutes a day for 15 days (about 3 weeks) over 6 weeks (about 1 and a half months). We will ask them to voice their opinion on the mathematics lessons and tasks their teacher assigns. They will do this in a separate room in the school building. Being in this study will not create any more risks than your child would face in a day. This study will not help them. Overall, we hope to gain information about how the CRMT affects CDL success in math.

**Purpose**
The goal of the study is to see how the CRMT instructional strategy helps students do well in math class. We ask your child to be in this study because they are CDL. We will ask for six CDL to be in this study.

**Procedures**
If your child wants to take part, they will voice their opinion on geometry math lessons or tasks for 20 to 30 minutes a day for 15 days (about 3 weeks) across 6 weeks (about 1 and a half months). These are the rules and duties:

- Your child must be in a math classroom.
- You must give permission if your child is under the age of 18.
- Your child must bring parental and student permission forms to the researcher before the deadline to join the study.
- The study will be at your child's school.
- The study will be during school hours.
- Your child may leave the study at any time without notice.
- Your child will finish a 20 to 30-minute math task per day for 16 days (about 2 and a half weeks).
- Your child's voice will be audio recorded while they complete the math task.

**Future Research**
We will delete your child's name and may use their data for future study. If we do this, we will not ask for any more consent from them.

**Risks**
In this study, there will not be any more risks than in a normal day of life. Your child will not get hurt from this study, but if they think they got hurt, call the research team as soon as possible. Georgia State University and the research team will not pay for any injury.

**Benefits**
This study does not help your child. Overall, we hope to gain information about how the CRMT affects CDL student work.

**Voluntary Participation and Withdrawal**
Your child does not have to be in this study. If they decide to be in the study and change their mind, they have the right to leave at any time. Your child may stop doing the task at any time. They may refuse to be in the study or stop at any time. This will not affect their grades in any way.

**Confidentiality**
We will keep your child's records private to the extent allowed by law. The following people will have access to the details they provide:

- Anu Krishna and Dr. Christopher Jett
- GSU Institutional Review Board
- Office for Human Research Protection (OHRP)

We will use your child's opinions, not their name, on study records. We will keep the details they gave us including their audio voice recordings on password- and firewall-protected computers. We will keep the consent forms and study data separately. When we present or publish the results of this study, we will not use your child's name or other details that may identify them.

**Contact Information**
Contact Christopher C. Jett at cjett2@gsu.edu or Anu Krishna at akrishna1@student.gsu.edu

- If you have questions about the study or your child's part in it
- If you have questions, concerns, or complaints about the study.

The IRB at Georgia State University reviews all research that involves human participants. You can contact the IRB if you want to speak to someone not involved with the study. You can contact the IRB for questions, concerns, problems, details, input, or questions about your child's rights as a research participant. Contact the IRB at 404-413-3500 or irb@gsu.edu.

_____ _____
Print Name Date

_____
Signature

_____ _____
Principal Investigator or Researcher Obtaining Consent Date

**Appendix B**

Student Assent Form

**Georgia State University**
**Student Informed Assent**

**Title:** THE IMPACT OF CULTURALLY RESPONSIVE MATHEMATICS TEACHING ON STUDENT ENGAGEMENT: A CASE STUDY OF A GEOMETRY CLASS

**Principal Investigator:** Dr. Christopher C. Jett

**Student Principal Investigator:** Anu Krishna

**Introduction and Details**
We are asking you to take part in a research study. It is up to you to decide if you would like to be in the study. The goal of this study is to see the result of Culturally Responsive Mathematics Teaching (CRMT) on culturally diverse student work in geometry mathematics class. You will need to spend about 30 minutes a day for 15days (about 3 weeks) over 6 weeks (about 1 and a half months). We will voice your opinion on mathematics lessons and tasks that your teacher does. Being in this study will not create any more risks than you would face in a day. This study will not help you. Overall, we hope to gain information about how the CRMT affects CDL success in math.

**Purpose**
The goal of the study is to see how the CRMT instructional strategy helps students do well in math class. We ask your child to be in this study because they are CDL. We will ask for six CDL to be in this study.

**Procedures**
If you want to take part, you will be asked to voice your opinion on a math lesson or task for 20 to 30 minutes a day for 15 days (about two weeks) across six weeks (about one and a half months). These are the rules and duties:

- You must be in a math classroom.
- Your parents must give permission if you are under the age of 18.
- You must bring parental and student permission forms to the researcher before the deadline to join the study.
- The study will be at your school.
- The study will be during school hours.
- You may leave the study at any time without notice.
- You will finish a 20 to 30-minute math task per day for 15 days (about 2 weeks).
- Your voice will be audio recorded while you complete the math task.

**Future Research**
We will delete your name and may use your data for future study. If we do this, we will not ask for any more consent from you.

**Risks**
In this study, there will not be any more risks than in a normal day of life. You will not get hurt from this study, but if you think you got hurt, call the research team as soon as possible. Georgia State University and the research team will not pay for any injury.

**Benefits**
This study does not help your child. Overall, we hope to gain information about how the CRMT affects CDL student work.

**Voluntary Participation and Withdrawal**
You do not have to be in this study. If you decide to be in the study and change your mind, you have the right to leave at any time. You may stop doing the task at any time. You may refuse to be in the study or stop at any time. This will not affect your grades in any way.

**Confidentiality**
We will keep your records private to the extent allowed by law. The following people will have access to the details you provide:

- Anu Krishna and Dr. Christopher Jett
- GSU Institutional Review Board
- Office for Human Research Protection (OHRP)

We will use your numbers, not your name, on study records. We will keep the details you gave us including your voice recordings on password- and firewall-protected computers. We will keep the consent forms and study data separately. When we present or publish the results of this study, we will not use your name or other details that may identify you.

**Contact Information**
Contact Christopher C. Jett at cjett2@gsu.edu or Anu Krishna at akrishna1@student.gsu.edu

- • If you have questions about the study or your part in it
- • If you have questions, concerns, or complaints about the study

The IRB at Georgia State University reviews all research that involves human participants. You can contact the IRB if you want to speak to someone not involved with the study. You can contact the IRB for questions, concerns, problems, details, input, or questions about your rights as a research participant. Contact the IRB at 404-413-3500 or irb@gsu.edu.

_____ _____
Print Name Date

_____
Signature

_____ _____

Principal Investigator or Researcher Obtaining Consent Date

**Appendix C**

Observation Rubric

**Date of Observation:**
**Observing Teacher:**

| **Standards of Mathematical Practice** | **Evidence** | **Artifacts** | **Notes** |
|---|---|---|---|
| 1. Make sense of the problems and persevere in solving them. | | | |
| 2. Reason abstractly and quantitatively. | | | |
| 3. Construct viable arguments and critique the reasoning of others. | | | |
| 4. Model with Mathematics. | | | |
| 5. Use appropriate tools strategically. | | | |
| 6. Attend to precision. | | | |
| 7. Look for and make use of structure. | | | |
| 8. Look for and express regularity in repeating reasoning (CCSSO & NGA, pp.6-8). | | | |

**Appendix D**

CRMT Lesson plans

| **Research Lesson Plans** |
|---|
| **Introduction** |
| The following anchor lessons were central to the research study on culturally responsive mathematics teaching (CRMT) and student engagement. Each lesson was designed to align with CRMT principles, cultural validation, collaboration, hands-on learning, and scaffolding, while also surfacing evidence of the Standards for Mathematical Practice (SMPs). These lessons served as focal instructional contexts for data collection, generating student artifacts, interviews, and observation notes that were analyzed thematically in Chapter 4. |

| **Instructional Sequence Overview** | | | |
|---|---|---|---|
| Anchor Lesson | Focus | Key Features | Connection to Research |
| Volume of Prisms and Cylinders | Applying the formula for volume to familiar objects such as bread, cereal boxes, and canned goods. | Students measured and calculated volumes, exchanged objects to verify accuracy, and applied formulas in problem-solving tasks. | Provided initial engagement data through artifacts and interviews; highlighted SMP 4 (Model with mathematics) and SMP 6 (Attend to precision). |
| Composite Shapes with Play-Doh | Creating and calculating the volume of composite 3D shapes using familiar solids (prisms, pyramids, cones, cylinders, spheres). | Students modeled and measured Play-Doh shapes in groups, decomposed them into simpler solids, and solved problems to calculate total volume. | Designed to highlight collaboration and hands-on learning, generated artifacts and interviews were analyzed for engagement. |
| Parallel City Project | Designing a city map using parallel lines, transversals, and angle relationships. | Students created city layouts with cultural landmarks, traffic signs, and buildings, embedding geometry into a familiar design context and solving angle problems within the design. | Served as a culminating CRMT activity to observe sustained engagement, collaboration, and creativity, and highlighted how CRMT supported engagement in abstract, less hands-on content. |

**Detailed Lesson Plans**

Instructional materials and de-identified student artifacts used in these lessons are provided in Appendix E.

**Lesson Plan 1. Volume: Prisms, Cylinders, and Composite Shapes**

**Purpose and Central Focus**

This lesson was designed as a core anchor task in the research study examining how culturally responsive mathematics teaching (CRMT) influenced student engagement in a high school geometry class. The central purpose was to connect the formula for volume (V = Area of Base × Height) to students' lived experiences using familiar cultural objects and hands-on modeling. By extending the lesson to composite shapes with Play-Doh, students engaged in both concrete measurement and creative modeling. The design intentionally created opportunities to observe behavioral, cognitive, and emotional engagement.

**Context in the Study**

The lesson was implemented with eight focal students who participated in the research study. It was part of the instructional sequence developed for data collection and served as one of the anchor lessons where student interviews, observations, and de-identified artifacts were collected and analyzed.

**Learning Objectives**

Apply the volume formula to prisms and cylinders using culturally familiar objects.
Construct and calculate the volume of composite solids through Play-Doh modeling.
Collaborate in small groups by measuring, calculating, verifying, and critiquing results.
Demonstrate engagement through hands-on tasks, peer collaboration, and application in problem-solving.

**Standards for Mathematical Practice (SMPs)**

SMP 1: Make sense of problems and persevere in solving them.
SMP 2: Reason abstractly and quantitatively.
SMP 3: Construct viable arguments and critique the reasoning of others.
SMP 4: Model with mathematics.
SMP 5: Use appropriate tools strategically.
SMP 6: Attend to precision.

**Culturally Responsive Design Features**

**Cultural validation:** Use of bread, cereal boxes, and canned food to connect formulas to household and community contexts.

**Hands-on collaboration:** Play-Doh modeling encouraged creativity and teamwork.
**Real-world application:** Measuring and analyzing familiar packaging reinforced relevance.
**Scaffolding:** Teacher modeling, guided examples, and structured group tasks supported connections between tangible objects and abstract formulas.

**Procedures**

**Introduction:** Bread and canned goods introduced prisms and cylinders, linking them to everyday contexts.

**Guided Exploration:** Teacher modeled one prism and one cylinder example, emphasizing accuracy and rounding.

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| **Group Task** – Prisms and Cylinders: Students measured and calculated volumes of assigned objects, then exchanged with peers to verify results. |
| **Group Task** – Composite Solids: Groups created composite solids using Play-Doh, decomposed them into simpler solids, and calculated total volume. |
| **Discussion:** Groups compared results, critiqued discrepancies, and highlighted precision. |
| **Closing Application:** Students solved assigned problems applying the volume formula to both familiar objects and composite solids. Artifacts were collected for analysis. |
| **Data Sources Generated** |
| Student artifacts (measurements, composite volume problems).<br>Researcher observations and field notes.<br>Interview responses referencing this lesson.<br>Engagement Evidence Targeted for Research<br>Behavioral: Measuring, building, and exchanging objects in groups.<br>Cognitive: Applying formulas, decomposing composite solids, verifying results.<br>Emotional: Expressing interest in familiar objects and creativity through modeling. |
| **Note.** Researcher reflections on this lesson are included in Chapter 4 as part of the triangulation of data sources. |

**Detailed Lesson Plans**
Instructional materials and de-identified student artifacts used in these lessons are provided in Appendix E.

**Lesson Plan 2. Parallel City: Parallel Lines and Transversals in Context**

**Purpose and Central Focus**

This lesson was designed to extend the study beyond tangible measurement tasks to a more abstract geometric concept: parallel lines and transversals. While the volume lesson emphasized hands-on engagement, the Parallel City Project required visualization, reasoning, and application of angle relationships in a culturally relevant design project. This deliberate shift provided an opportunity to observe how CRMT strategies supported engagement when mathematical content was less concrete.

**Context in the Study**

The lesson was implemented with the same focal students as part of the instructional sequence for data collection. It served as a second anchor task to contrast with the volume lesson. Students collaboratively designed "Parallel City" layouts that embedded parallel lines, transversals, and angle relationships into a city design featuring cultural landmarks and personal references. Data included student artifacts, interviews, and observation notes.

**Learning Objectives**

Apply properties of parallel lines and transversals to construct and analyze geometric relationships.
Collaborate to design a culturally meaningful city layout that embeds geometric reasoning.
Observe how CRMT strategies influence engagement when the task is abstract rather than hands-on.

**Standards for Mathematical Practice (SMPs)**

SMP 1: Make sense of problems and persevere in solving them.
SMP 2: Reason abstractly and quantitatively.
SMP 3: Construct viable arguments and critique the reasoning of others.
SMP 4: Model with mathematics.
SMP 6: Attend to precision.

**Culturally Responsive Design Features**

Cultural validation: Students incorporated local landmarks, cultural references, and community features into city designs.
Collaborative structures: Group planning and critique encouraged shared problem-solving.
Real-world application: City planning emphasized geometry's relevance in infrastructure and design.
Scaffolding: Teacher prompts and guiding diagrams supported students in connecting geometric rules to creative layouts.

**Procedures**

**Introduction:** The teacher presented the design challenge: building a city where streets followed parallel line rules.

**Guided Exploration:** Teacher modeled an example with parallel lines, a transversal, and identified angle relationships.

| |
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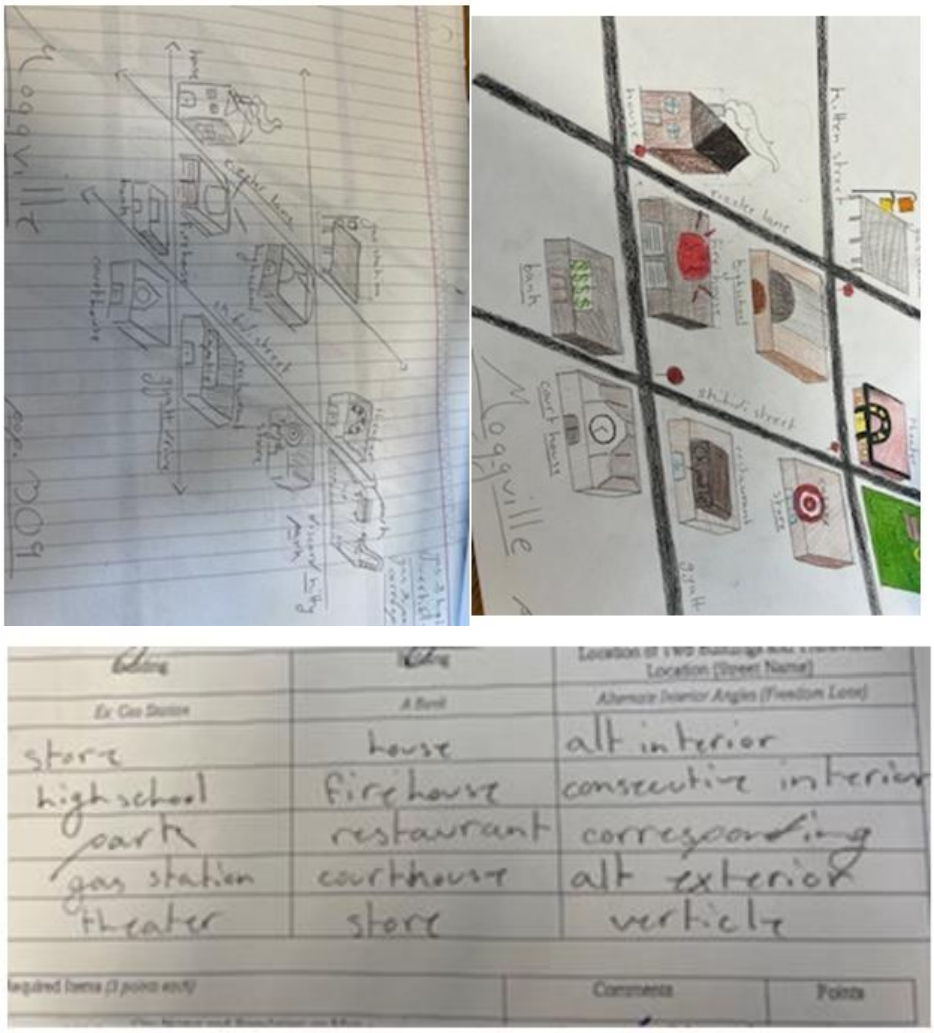
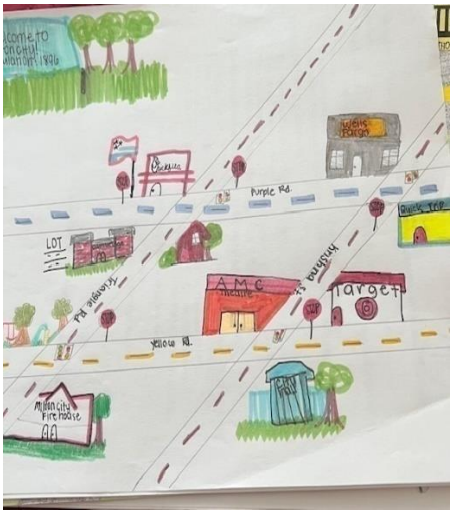
| **Group Task:** Students designed city layouts with multiple parallel streets, transversals, and intersections, labeling angles and including cultural landmarks. |
| **Discussion:** Groups presented their city designs, explaining geometric choices and critiquing peers' reasoning. |
| **Closing Application**: Students applied parallel line and transversal rules to solve problems within their city designs. Artifacts were collected for analysis. |
| **Data Sources Generated** |
| Student city design artifacts (Appendix E).<br>Researcher observation notes.<br>Interview excerpts referencing this lesson.<br>Engagement Evidence Targeted for Research<br>Behavioral: Participation in group design and presentation.<br>Cognitive: Application of geometric rules in abstract contexts; critique of peers' designs.<br>Emotional: Pride and interest in embedding cultural references into creative city layouts. |
| **Note.** Researcher reflections on this lesson are included in Chapter 4 as part of the triangulation of data sources. |

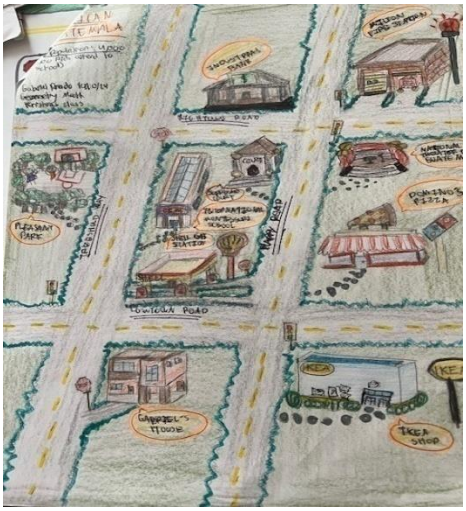
## Appendix E

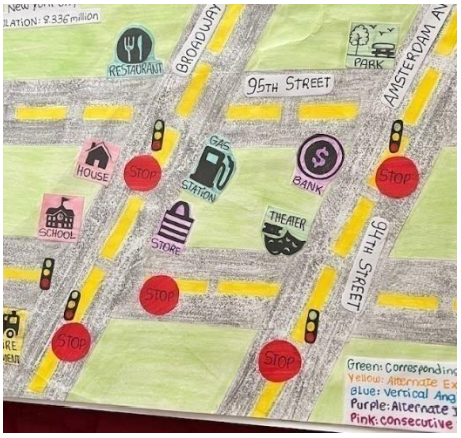
*Figure E1*

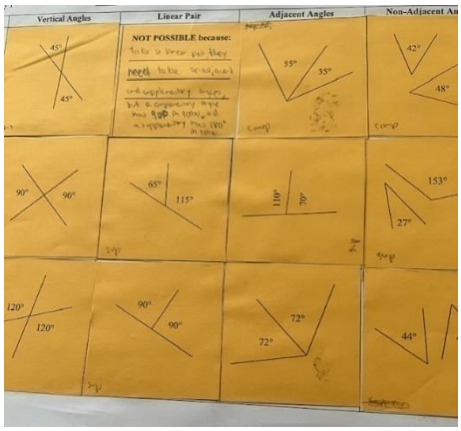
*Culturally responsive Parallel City activity artifacts*






| Building | Building | Location of Two Buildings and Transversal Location (Street Name) |
|---|---|---|
| Ex: Gas Station | A Bank | Alternate Interior Angles (Freedom Lane) |
| Park | Theater | corresponding Angles |
| Fire Department | the courthouse | Alternate Exterior |
| Gas Station | Restaurant | Vertical Angles |
| Bank | Store | Alternate Interior |
| My house | High School | Consecutive Interior |

## Appendix F

Interview Questions

The purpose of these semi-structured interviews was to understand how students experienced and engaged with CRMT strategies during a high school geometry unit. The protocol was aligned with the study's research questions, the CRMT framework, Fredricks et al.'s (2004) tripartite model of engagement (behavioral, emotional, cognitive), and the SMPs. Semi-structured interviews were selected for their flexibility and depth, allowing participants to share perspectives in their own words (Merriam, 1998; Stake, 1995).

### Background and Classroom Experience

1. Can you describe your general feelings about learning mathematics before this unit began?
2. How would you describe your typical level of participation in past math classes?

### CRMT Strategies and Engagement

3. During this geometry unit, lessons included activities such as using familiar objects for volume, working with Play-Doh shapes, and designing Parallel City. How did these types of activities compare to your usual math lessons?
4. What parts of these lessons felt most engaging or interesting to you? Why?
5. Were there times when you felt less engaged? What factors contributed to that?

### Collaboration and Identity

6. How did working with peers in group activities affect your participation and learning?
7. Did you see any connection between the lessons and your own experiences, culture, or community? If so, can you give an example?

### Standards for Mathematical Practice (SMPs)

8. In some activities, you explained your reasoning, modeled with real-world examples, or looked for patterns and structure. How did these practices affect your engagement with the lessons?
9. Can you describe a time when you felt challenged to think more deeply or explain your ideas clearly during the lessons?

### Reflection and Impact

10. Looking back on the unit, how do you think these lessons influenced your confidence or interest in mathematics?

11. If you could change or add something to make these lessons more engaging, what would you suggest?

**Closing Script (Read Aloud to Participants)**

Thank you for sharing your thoughts. Your input is very valuable in helping me understand how teaching strategies can support student engagement in math. If you would like to review your transcript or add any additional comments later, please let me know. Do you have any final thoughts you would like to share?

**Notes:**

Follow-up prompts such as “Can you tell me more?” or “What made you feel that way?” were used to encourage elaboration.

Reflexive notes were taken immediately after each interview to document contextual details and emerging insights.