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Exploring Culturally Responsive Equitable Problem-Solving Pedagogy: Theorizing, Developing & Teaching

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EXPLORING CULTURALLY RESPONSIVE EQUITABLE PROBLEM-SOLVING PEDAGOGY: THEORIZING, DEVELOPING & TEACHING

by

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ABSTRACT

EXPLORING CULTURALLY RESPONSIVE EQUITABLE PROBLEM-SOLVING PEDAGOGY: THEORIZING, DEVELOPING & TEACHING

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Old Dominion University, 2023
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Achievement gaps in mathematics between middle and high school Black students when compared to their white peers exist in part because of access, but also because Black learners' brilliance is not recognized. Finding ways to help students, especially Black students, become successful mathematical problem solvers was a driving force behind this research. The purpose of this research is to explore ideas of how to improve Black students' opportunities to engage in effective mathematical problem solving to improve their mathematics understanding and achievement. This study introduces the Culturally Responsive Equitable Problem Solving (CREPS) pedagogy situated at the intersections of a conceptual framework comprised of three pedagogies - Gay's (2002) Culturally Responsive Pedagogy, Aguirre, Mayfield-Ingram, and Martin's (2013) Equity-Based Mathematics Practices, and Schroeder and Lester's (1989) Teaching *through* Problem-Solving.

This dissertation study is guided by several research questions and reported through three separate, but related essays: (a) *Theorizing a Culturally Responsive Equitable Problem-Solving Pedagogy;* (b) *Developing Culturally Responsive Equitable Problem-Solving Pedagogical Knowledge*; and (c) *Cases of Exemplary Instances of Teaching Culturally Responsive Equitable Problem-Solving Pedagogy.* These three essays introduce and explain the tenets of CREPS pedagogy, examine secondary mathematics teachers' culturally responsive teaching readiness and their professional learning of CREPS through CREPS pedagogy, and identify

instances of exemplary CREPS pedagogical teaching during lesson study (i.e., collaborative planning and iterative teaching of a CREPS lesson), respectively. There were several findings from this research. The most salient findings were the three CREPS pedagogical moves: (a) development of deep mathematics understanding; (b) acknowledgement of students' backgrounds; and (c) employment of equitable pedagogical practices. Several ideas for future research are shared related to refining and testing the CREPS pedagogy, developing teachers' CREPS pedagogical knowledge, and teaching experiments for enacting CREPS pedagogy.

This dissertation is dedicated to that special person. I do not have to mention the name because they already know who they are. If you feel the need to ask or even wonder if I am referring to you, then you are not the one. In addition, I dedicate this dissertation to those who have been the guiding lights in my life, inspiring me to pursue knowledge, pushing me to exceed my own expectations, and supporting me through every twist and turn of this journey.

ACKNOWLEDGMENTS

I am profoundly grateful and elated to have reached this significant milestone in my academic journey – the completion of my dissertation. This endeavor would not have been possible without the support, encouragement, and contributions of numerous individuals, who have touched my life in unique ways. In this acknowledgement, I extend my sincerest appreciation to all those who have been instrumental in the successful completion of this work.

First and foremost, I thank my Lord and Savior, Jesus Christ. I give honor to God, who is the head of my life and the reason why I am here. Soon after I was accepted into Old Dominion University's Curriculum and Instruction Doctoral program, grief fell upon me. I was diagnosed with stage 2B breast cancer. I was confused, lost, and baffled. I thought, why me? over and over. I pondered and contemplated the decision to further my education. These past years have been the hardest with doctors' appointments after doctors' appointments, surgeries after surgeries, emotionally taxing chemotherapy, and radiation treatments, all while continuing to work a full-time job and in addition, chose to continue my life as a full-time doctoral student. I struggled with adjusting to my norm of life, but I also wanted the victor's cup. My new life has been crafted with tough side effects and long term-medications, but I am reminded that I am determined, serious about education, and tenacious. Through God's grace and mercy, I am adjusting to my new norm of life. My motivation to continue comes from the bible verse, "No weapon formed against me shall prosper." (Isaiah, 54:17) – Is this APA format? ☺

I express my heartfelt gratitude to my dissertation chair and committee members, the A-Team. That is what they called themselves. "A" for awesome, amazing, accomplished, admirable. Not sure what they meant the "A" to stand for but those are the words that come to mind when I think of them. To my dissertation chair, Dr. Melva Grant, thank you for your

unwavering guidance, invaluable insights, and continuous support throughout the research process. Your expertise and dedication have been an immense source of inspiration for me, guiding me in refining my ideas and shaping my research into a meaningful contribution to research. Through this journey you were more than a professor, advisor, or chair, you were a friend. I am indebted to my dissertation committee - Dr. Judith Dunkerly, Dr. Kala Burrell-Craft, and Dr. Laura Smithers – for their invaluable feedback and constructive criticism during the various stages of my research. Their diverse perspectives and expertise have helped shape my dissertation into a comprehensive and well-rounded study. Thank you for encouraging me to believe in myself.

I am humbled and grateful for the immense support I have received from each member of my family. To my parents, Burnett and James, I cannot thank you enough for your unwavering belief in me and your unending encouragement throughout this challenging journey. Your constant love, guidance, and sacrifices have been the driving force behind my pursuit of knowledge. Your belief in my abilities, even in times of doubt, has given me the confidence to persevere and overcome obstacles. You have been my pillars of strength, and I owe this achievement to your unwavering support. To my sister, Latasha, thank you for your constant encouragement and support during this academic pursuit. Thank you to my children, Tanese, Tyric, and my grandbaby Jessiah, for your boundless love and understanding as I balanced my academics with family life. Your smiles and laughter have brightened my days, and you have been a constant reminder of the purpose and meaning behind my academic endeavors.

Lastly, I owe a special debt of thanks to my friends and classmates who supported and encouraged me through the highs and lows of this journey. Their camaraderie and willingness to lend a helping hand during challenging times were immeasurable and deeply appreciated. To my

good friend and accountability partner, Robyn, thank you for the support you have extended through my dissertation journey. I am also thankful to all the participants who generously volunteered their time and insights for my research. Their cooperation and willingness to share their experiences have been integral to the validity and relevance of my findings.

Completing this dissertation has been a journey of self-discovery, perseverance, and growth. The valuable lessons learned, and the skills acquired will undoubtedly shape my future academic pursuits and professional endeavors. Once again, I extend my deepest gratitude to all those who have contributed to the successful completion of my dissertation. Your support and encouragement have made this achievement possible, and I am humble and grateful beyond words.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table Page

LIST OF FIGURES

CHAPTER I

INTRODUCTION

"Not everything that is faced can be changed but nothing can be changed until it is faced."

~James Baldwin

James Baldwin, a Black author and poet, delivered this quote in 1962 and six decades later, it still rings true today. This well-known quote significantly confronts problems and situations that individuals face. Baldwin used this quote specifically to address the Black experience in a predominantly white society. His insightful thoughts on change and facing problems examines systemic racism whether in housing, healthcare, education, politics. In the case of this dissertation, I acknowledge inequity in mathematics education as systemic and real.

The National Council for Teachers of Mathematics (NCTM) has proposed for a long time that equity in mathematics teaching is important proclaiming that "mathematics education of every child is its most compelling goal" (NCTM, 1989, p. 4) and "excellence in mathematics education rests on equity-high expectations, respect, understanding, and strong support for all students" (NCTM, 2000, p. 11). Despite the research advances in teaching, learning, curriculum, and assessment, Black student achievement continues to lag that of other groups in the United States with little change, signaling that the needs of these students are not being addressed (Martin et al., 2010). The persistent performance differences in secondary mathematics between Black and white students highlights that Black students are denied access to equitable mathematics teaching and opportunities to learn. This research explored ideas of how to improve Black students' opportunities to engage in effective mathematical problem solving to improve their mathematics understanding.

Problem Statement

Mathematics achievement of Black students is compared with that of white students by means of state and national assessments. The National Assessment of Educational Progress (NAEP) assessment measures students' knowledge and skills in mathematics as well as problem solving in mathematical and real-world contexts. Table 1 shows the pre and post pandemic scores for the NAEP mathematics assessment.

Table 1.

National Assessment of Educational Progress (NAEP) 2019/2022 Data

Student Group	4th Graders' Scores Pre/Post COVID	8th Graders' Scores Pre/Post COVID
Black Students	224/217	260/253
White Students	249/246	292/285

Pre-pandemic data from the NAEP assessment shows that among racial/ethnic groups the average mathematics score for Black fourth grade students was 224, which is 25 points lower than their white peers. The average mathematics score for Black eighth grade students was 260, which is 32 points lower than their white peers. The most recent data from the NAEP assessment shows that among racial/ethnic groups the average mathematics score for Black fourth grade students was 217, which is 29 points lower than their white peers. The average mathematics score for Black eighth grade students was 253, which is 32 points lower than their white peers. The score differences between Black and white students have persisted since the first NAEP assessment in 1990.

The Virginia state mathematics end of year (EOY) assessment for grades 3 through 8 from 2019 to 2022 also shows the trend of Black students performing significantly lower than their white peers (see Table 2).

Table 2.

Virginia State Mathematics EOY Assessment Pass Rates by Student Groups for 2019 - 2022

Student Group	2019 Pre COVID	2021 During COVID	2022 Post COVID
Black Students	70%	34%	49%
White Students	88%	64%	76%

Pre-pandemic state mathematics end of year pass rate for Black students was 24 percentage points lower than that of white students. The first test after the pandemic in 2021, the gap widened to 30 points. Then in 2022, the post-pandemic pass rate gap was 27 points, which reflected a slight decrease from 2021, but was still larger than the pre-pandemic gap.

Results from the NAEP and the Virginia state annual standardized mathematics assessments reveal a hard truth; Black students are consistently performing lower on mathematics standardized achievement tests when compared to their white peers, the achievement gap is persistent, and it has not closed in any meaningful way. For some scholars, there is a sense of urgency to promote mathematics education to address the growing diversity of school populations and to place emphasis on improving students' mathematics achievement (e.g., Aguirre et al., 2013; Martin, 2012, 2019). Yet, there are many barriers and challenges about how to reach that goal. One path of research and professional development that has gained support in this area focuses on culturally responsive mathematics teaching (CRMT) - "a specific pedagogical knowledge, dispositions, and practices that privilege mathematical thinking,

culturally and linguistic funds of knowledge, and issues of power and social justice in mathematics education" (Aguirre & del Rosario Zavala, 2013, p. 163). Gay (2010) posited that teachers need appropriate preparation and training to become culturally responsive mathematics teachers. Despite a great deal of research about mathematics problem-solving, there is little known about the potential for culturally responsive teaching and problem-solving and the influence on Black achievement. However, given the persistent mathematics achievement gap from the United States K-12 schools, something more is needed, and according to Martin (2012), few researchers have attempted to apply mathematical problem-solving frameworks with Black children.

Purpose Statement and Research Questions

The purpose of this research is to explore ideas of how to improve Black students' opportunities to engage in effective mathematical problem solving to improve their mathematics understanding and achievement. In addition, this study examined teachers' readiness to teach using culturally responsive practices, and to capture secondary mathematics teachers' learning experiences as they participated in professional learning situated in culturally responsive equitable problem-solving pedagogy. Lastly, this study examined secondary mathematics teachers with emergent understanding of culturally responsive equitable problem-solving pedagogy as they participated in iterative teaching via lesson study. The following research questions guided this study:

> **RQ1:** At what levels do secondary mathematics teachers from a large predominantly Black school district rate their readiness for teaching as measured by the Culturally Responsive Teaching Readiness Scale?

RQ2: How do secondary mathematics teachers from a large predominantly Black school district perceive culturally responsive teaching?

RQ3: How do you prepare secondary mathematics teachers to understand Culturally Responsive Equitable Problem Solving (CREPS) Pedagogy?

RQ4: How do in-service secondary mathematics teachers, with an emergent understanding of the CREPS pedagogy, enact its features through collaborative planning and iterative teaching?

The answers to these questions will be articulated through three distinct essays and will contribute to the scholarship that investigates the ways culturally responsive equitable problem-solving pedagogy is useful in making mathematics accessible to Black students.

Significance and Relevance

The significance of this research study is that it will contribute to the body of work surrounding the teaching of mathematical problem solving to Black students in efforts to close the achievement gap by increasing opportunities for learning. This research study may benefit both students and teachers in three ways:

- capitalizing on students' funds of knowledge by providing students with the opportunity to relate the learning of mathematics to their cultural background knowledge which assists students in developing their cultural identities and perceptions of themselves as capable learners of mathematics.
- encouraging the use of higher-level thinking skills that involve analyzing, reasoning, and evaluating by preparing them to use multiple strategies to solve problems and justify their solutions.

- practicing ongoing self-reflection and teacher examination of their own beliefs, values, and perceptions about race, ethnicity, and culture and how they intertwine to shape their students' learning experiences.

This research also has the potential to influence organizations and interested parties to creatively approach culturally responsive equitable problem-solving pedagogy as an interruption of traditional problem-solving teaching and perhaps diminish the racial achievement gap. Policymakers need to recognize the significance and the benefits of culturally responsive equitable problem-solving pedagogy by designing and funding professional learning to prepare teachers. There is a need to develop teachers who include culturally responsive equitable problem-solving pedagogy as a part of the practices when teaching Black students. These pedagogical practices can be continued during in-service teaching by providing ongoing culturally responsive mathematics professional development. Subsequently, leadership will have to support teachers in making changes in how mathematics is taught to Black students. Pushing for change in how teachers are prepared to teach mathematics can help foster environments for Black students to achieve.

Three-Essay Dissertation Structure

This dissertation includes the introductory chapter, three essays, and a concluding chapter. Each of the three essays is designed around standalone research questions, addressed through relevant literature, data sources, analysis, findings, and discussions. All three essays explore the relationship between culturally responsive teaching, equity-based practices in mathematics classrooms, and teaching *through* problem solving.

Essay One

Essay one describes the culturally responsive equitable problem-solving pedagogy, which builds on three pedagogical ideas: Gay's (2002) Culturally Responsive Teaching, Aguirre, Mayfield-Ingram, Martin's (2013) Equity-Based Mathematics Practices, and Schroeder and Lester's (1989) Teaching *through* Problem-Solving. This was developed as a lens to examine mathematical problem-solving practices used to teach Black students. This essay explored how education scholars have discussed the intersection of Culturally Responsive Pedagogy (CRP), Equity-Based Mathematics Practices, and Teaching *through* Problem-Solving in mathematics classrooms to situate and position a conceptual framework for developing teaching practices that infuse Culturally Responsive Equitable Problem-Solving (CREPS) pedagogy. In addition, this essay introduces the culturally responsive equitable problem-solving pedagogy as a conceptual framework for teaching mathematical problem-solving for Black students.

Essay Two

Essay two employed a mixed methods methodology, whose aim was to understand whether teachers believed they were ready to teach in a culturally responsive way and to capture teachers' perceptions as they participated in professional development designed to introduce the CREPS pedagogy. This study was guided by the research questions below:

RQ1: At what levels do secondary mathematics teachers from a large predominantly Black school district rate their readiness for teaching as measured by the Culturally Responsive Teaching Readiness Scale?

RQ2: How do secondary mathematics teachers from a large predominantly Black school district perceive culturally responsive teaching?

RQ3: How do you prepare secondary mathematics teachers to understand Culturally Responsive Equitable Problem Solving (CREPS) Pedagogy?

The data collected for this mixed method study included information collected from the culturally responsive teaching readiness scale and analyzed using descriptive statistics. The data collected also included audio recordings of the professional development session and participant reflection journals. Themes and patterns from these data were developed using In Vivo coding.

Essay Three

Essay three used a case study research design that captured effective examples of the CREPS framework when it is being enacted through the lens of teachers whose CREPS knowledge is emerging. The following research question will guide this case study: How do in-service secondary mathematics teachers, with an emergent understanding of the CREPS pedagogy, enact its features through collaborative planning and iterative teaching? To address the question, a lesson study was used as a vehicle for exploring the enactment of the CREPS framework. The data sources included video recording of the lesson study meetings and classroom observations. Other sources of data collection included iterations of the lesson plan, the teacher's written reflections, and student work. Themes and patterns from transcriptions were developed using In Vivo coding.

Organization of the Dissertation

Chapter 1 presented a brief overview of the research study, including an introduction to the background of the study, the problem statement, the purpose statement and research questions, and the significance and relevance. A description of the three essays followed. The remainder of the study is organized in a three-essay format. Chapter 2 presents an essay that will review related literature and introduce the conceptual framework that guided the research. Chapter 3 presents an essay that will assist in understanding whether teachers believed they were ready to teach in a culturally responsive way. In addition, it will capture teachers' perceptions as

they participate in professional development designed to introduce the CREPS pedagogy. Chapter 4 presents an essay that captures effective examples of the CREPS pedagogy when it is being enacted through the lens of teachers whose CREPS knowledge is emerging. Chapter 5 presents the conclusion to the research study. It provides a synthesis of the three essays.

CHAPTER 2

ESSAY 1 – THEORIZING A CULTURALLY RESPONSIVE EQUITABLE PROBLEM-SOLVING PEDAGOGY

Achievement gaps in mathematics between middle and high school Black students when compared to their white peers are more often denied access to equitable mathematics teaching (Aguirre et al., 2013; Aguirre et. al., 2017; Confrey, 2010; Martin et.al., 2010; Martin, 2013, 2019). Given this historical context, there must be a sense of urgency to implement instructional practices that level the opportunities for Black mathematics learning. There has been considerable research on teaching mathematical problem-solving (Cai, 2003; Cai & Hwang, 2002; Lesh & Zawojewski, 2007; Lester, 1994, 2013; Schoenfeld, 1985, 1992, 2013; Silver, 1985). Despite a great deal of research in mathematics education research about mathematical problem solving, researchers still know very little about the potential for culturally responsive equitable problem-solving pedagogy to help all children, and especially Black children develop stronger problem-solving skills. The continued inequitable practices present in K-12 schools in the United States suggest that more research is needed to determine how culturally responsive equitable problem-solving pedagogy might influence mathematics learning.

Finding ways to help students, especially Black students, become successful mathematical problem solvers was the driving force behind my research. How should this be done? What or who is contributing to their inability to become successful mathematical problem solvers? Who has a significant impact on a student's ability to be successful mathematical problem solvers? With pressures placed on educators, revealing relevant instructional strategies is necessary to help teachers and students be successful. The purpose of this research is to explore ideas of how to improve Black students' opportunities to engage in effective

mathematical problem solving to improve their mathematics understanding and achievement. This essay explored how education scholars have discussed the intersection of Culturally Responsive Pedagogy (CRP), Equity-Based Mathematics Practices, and Teaching *through* Problem-Solving in mathematics classrooms to situate and position a conceptual framework for developing teaching practices that infuse Culturally Responsive Equitable Problem-Solving (CREPS) pedagogy.

Significance of CREPS Pedagogy to Mathematics Education

With the publication of *The Brilliance of Black Children in Mathematics: Beyond the Numbers and Toward New Disclosure* (Leonard & Martin, 2013), there has been a boost in research in mathematics education devoted to unpacking the teaching practices needed to teach Black students. Rather than blaming students, their families, or their communities, this publication identifies outside factors that sustain Black students' systematic marginalization. In addition to this publication, Martin (2019) asserted,

> I suggest that those who believe in the humanity of Black people actively resist and reject mathematics education that results in epistemological violence and mathematics reforms that perpetuate antiblackness. … Instead, research in service to acknowledge and valuing Black humanity can start with the axiom of Black learners' brilliance (p. 471).

Martin (2019) supports disrupting normative discourses about Black students and mathematics. I assert that mathematics education researchers interested in studying teaching practices that help Black students begin from Martin's standpoint of Black learners' brilliance coupled with a framework conceptualized for Black students. I offer CREPS pedagogy, my theoretical conceptualization that connects black culture, equity, and mathematical problem-solving.

Literature Review

When examining why Black students are not experiencing the successes in mathematics as their white peers, findings of published work point to implementing teaching practices related to being culturally responsive, equitable, and approaches to teaching *through* problem-solving to explain how they can be successful. Moreover, these three pedagogies are directly related to the development of the teaching practices related to CREPS pedagogy. Because this is my novel conception of a pedagogy for Black children, there is no research focused on the integration of these three pedagogies, so I begin with an examination of the research on each of them separately.

Culturally Responsive Teaching

Recent research on culturally responsive mathematics teaching have focused on deriving information from specific research in the form of synthesis studies, meta-analysis, and systematic literature reviews (e.g., Abdulrahim & Orosco, 2020; Aronson & Laughter, 2016; Thomas & Berry, 2019). Aronson and Laughter (2016) conducted a literature synthesis to find examples of research connecting culturally responsive education to positive student outcomes across content areas. They produced more than 280 results across all subject areas but synthesized only 8 studies in mathematics. On the other hand, Thomas and Berry (2019) conducted a qualitative metasynthesis that produced 1,224 math education articles and synthesized 12 studies to understand how researchers interpreted mathematics teaching practices that supported culturally responsive teaching and culturally relevant pedagogy in grades PK-12. Unlike the other two synthesis', Abdulrahim and Orosco (2020) conducted a synthesis of 35 studies that targeted mathematics teaching to culturally and linguistically diverse learners.

Implementing culturally responsive practices makes a difference in the academic success of culturally diverse students (Bonner, 2014; Borck, 2020; Farinde-Wu et al., 2017; Harding-Dekam; 2014; Milner, 2016; Nicol et al., 2013). More specifically, there are significant findings from several studies that substantiate culturally responsive mathematics teaching as an important factor in the mathematics success of Black students (Bonner, 2014; Harding-Dekam; 2014; Milner, 2016; Nicol et al., 2013). Nicol et al. (2013) pointed out how poor teaching strategies can make students believe that mathematics is difficult and unattainable. These researchers shared examples of how teachers adapted applied math questions to their own classroom settings, affording students opportunities to relate to the questions in ways that reflect their own culture. In Bonner's (2014) study that explored culturally responsive practices of three teachers teaching underserved students, she found that part of their success was due to incorporating diverse instructional techniques including movement, clapping, rhythm, dance, oral storytelling, and choral responses that aligned with some students' cultural norms. Similarly, Harding-Dekam (2014) investigated how 8 elementary math teachers of diverse students successfully incorporated their students' cultural knowledge into their mathematics teaching. This researcher attributed her success to understanding the individual students' home and community life, the defining of culturally responsive mathematics teaching practices consistent with research, through examples of how students learn math through culture, and self-identifications of diversity. Empirical evidence largely supports the implementation of culturally responsive mathematics teaching practices to improve Black students' success in mathematics.

Equity-Based Practices in Mathematics Classrooms

Recent research on implementing equity-based practices in secondary mathematics classrooms has both successes and challenges (e.g., Dunleavy, 2015; Gregson, 2013; Rubel,

2017). For example, Dunleavy (2015) found that the use of cooperative learning as an instructional practice was an important aspect of an equitable mathematics classroom and thus classified its use as successful. The researcher posited the reason for these practices was for equal participation in mathematics classrooms by promoting equitable opportunities to learn. Despite the successes, Gregson (2013) found that some teachers felt that when there was little mathematics emphasized in her lesson plans that "valuable time may be lost" (p. 186). The teacher was concerned about whether the lesson included enough math and how much weight was given to various teaching objectives. Similarly, Rubel (2017) found that teachers demonstrated excellence with dominant dimensions of equity but found it a challenge when implementing practices that corresponded to critical dimensions. For example, teachers were successful when they implemented lessons centered on high-demand tasks, active student participation, and making connections across representations and sensemaking. Teachers had challenges in connecting to student's experiences and teaching critical mathematics such as teaching for social justice. When mathematics lessons included contents related to power and social justice, mathematics teachers avoided addressing those topics in class or they engaged these issues superficially by just introducing the topics and not discussing the inequities and prejudices.

Teaching *through* problem-solving

Research supports the claim that students should not be taught problem-solving strategies and heuristics, including how and when to use them, because it is not effective in determining whether students become better at problem-solving (e.g., Chapman, 2017; Lesh & Zawojewski, 2007; Lester, 1994; Schoenfeld, 1985, 1992). Chapman (2017) conducted a study with three high school teachers that showed exemplary pedagogical skills for teaching *through* problem-solving

and how it contributed to them effectively supporting students' engagement with problem-solving. Teachers felt that one of the key strategies is to not teach heuristics or concepts in an explicit way, which is a characteristic of teaching *about* problem-solving, but to allow them to emerge from students' experiences when trying to solve a problem. Researchers offer insights about how to assist teachers in showing exemplary pedagogical skills for teaching through problem-solving that include the selection of appropriate tasks and classroom discourse (Cai, 2003; King, 2019; Lester 2013, Van de Walle et al., 2019). King (2019) studied the effects of graduate mathematics education courses using a teaching model based on teaching *through* problem-solving. Results showed that in-service teachers' ability to create genuine problems improved after working through the instructional model and discussed a new role for communication in the mathematics classroom. Watanabe et al. (2019) conducted a lesson study to develop and nurture mathematics teachers' capacity to teach *through* problem-solving. They found that participants thought their participation in the lesson study helped them teach mathematics *through* problem-solving by trusting their students' ability to be mathematical problem solvers and improving their own ability to analyze students' responses to mathematics problems. Empirical evidence from recent research largely supports the need to provide teachers with opportunities to analyze mathematical ideas and make connections in instructional situations.

Summary

Mathematics practices, such as teaching *through* problem-solving, culturally responsive teaching, and equity-based mathematics teaching, challenge many teachers' beliefs, knowledge, practices, and cultural norms. The goal of this literature review was to determine how researchers addressed the intersection of teaching *through* problem-solving, culturally responsive teaching,

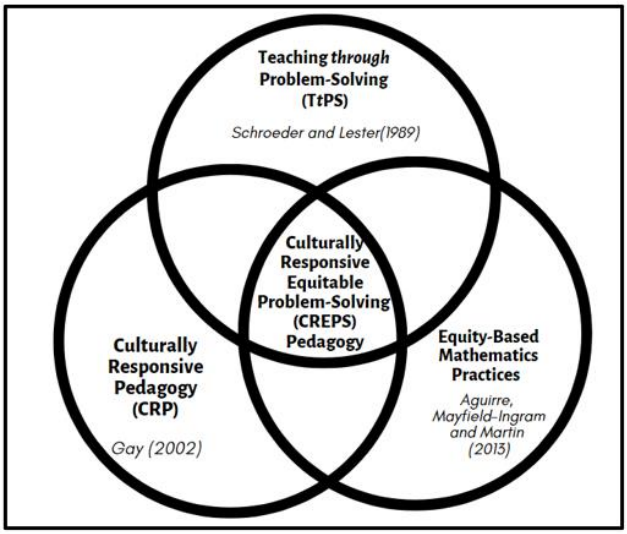
and equitable mathematics teaching practices for Black students in secondary schools. Moreover, this literature review noted how researchers addressed the need to support teachers in enacting these approaches to teaching mathematics by providing opportunities to engage in targeted professional development. Although scarce, there is literature that supports each approach, however, each is addressed individually and not as an intersection. This presents a void in the literature, therefore the integration of the three approaches situated in professional learning as a conceptual framework, CREPS pedagogy, is proposed below.

Culturally Responsive Equitable Problem-Solving Pedagogy Conceptual Framework

In developing the conceptual framework of CREPS pedagogy (see Figure 1), I used the intersection of three pedagogical ideas: Gay's (2002) Culturally Responsive Teaching, Aguirre, Mayfield-Ingram, Martin's (2013) Equity-Based Mathematics Practices, and Schroeder and Lester's (1989) Teaching *through* Problem-Solving. I assert that the proposed CREPS pedagogy is situated in the intersection of the three pedagogies designed to see Black children's brilliance (see Figure 1).

Figure 1.

A Framework for Developing CREPS Pedagogy



Culturally responsive pedagogy is a framework that can be viewed as an umbrella that encompasses successful pedagogical practices for Black children. Equity-based practices in mathematics classrooms is a framework that strengthens mathematical learning and cultivates positive student mathematical identities. Teaching *through* problem-solving is an approach that means students learn through inquiry and exploration. At the root of CREPS pedagogy is the belief that Black students can be successful mathematical problem solvers and sense makers when teachers implement these pedagogies. When these pedagogies are merged and situated for sense making within mathematics learning, they make a powerful pedagogy for teaching mathematical problem-solving to all students, including Black students. In the sections that follow, each pedagogy will be described along with its theoretical foundations.

Mathematics Teaching *through* Problem Solving

Mathematical problem-solving has been for decades and continues to be an important part of mathematics education. Problem-solving is fundamental to everyday life. Incorporating problem-solving into mathematics instruction has gained widespread acceptance (NCTM 1980; Schroder & Lester, 1989), but teachers have struggled with how it should be implemented. Schroder and Lester (1989) described three different approaches that emerged in problem-solving instruction: teaching *for* problem-solving, teaching *about* problem-solving, and teaching *through* problem-solving.

The most common pedagogical approach to mathematical problem-solving is teaching *for* problem-solving, which focuses on the acquisition of mathematical knowledge and the ability to use the learned knowledge in a practical context (Boaler, 2002; Schoenfeld, 2013; Van de Walle et.al., 2019). Specifically, teachers begin by teaching the abstract concept as a procedure or skill, the students practice the skill, and then they apply the learned using word problems. Many

traditional textbooks were written using this pedagogy, show or tell, practice, and then apply the skill using uncomplicated word problems. The limitation of this approach is that students learn that the word problems they encounter will be solved using the skill they just learned (Schoenfeld, 2013; Van de Walle et. al., 2019). Therefore, there is no reason to read and understand the word problem. Often students lift the numbers out and organize them according to the procedure or the skill and compute an answer. This approach has resulted in students having difficulty with story problems, multi-step word problems, and solving rich mathematical tasks (Boaler, 2016).

Teaching *about* problem-solving is the pedagogy of strategies that can help solve problems. Most strategies *about* problem-solving emerged from George Polya (1945), a mathematician, who founded a four-step heuristic: understand the problem, devise a plan, carry out the plan, and look back. Heuristic is the process of allowing a person to discover something for themselves (Polya, 1945). The limitation of this process is that "instead of problem-solving serving as a context in mathematics is learned and applied, it may become just another topic, taught in isolation from the content and relationships of mathematics" (Schroeder & Lester, 1989, p. 34). Ultimately, teaching *for* problem-solving and teaching *about* problem-solving are not beneficial in preparing students to be effective problem solvers.

The most important problem-solving pedagogy for learning mathematics and sense making is teaching *through* problem-solving. Teaching *through* problem-solving is a pedagogy that relies on students learning mathematics through inquiry by exploring real contexts, problems, situations, and models (Schroeder & Lester, 1989; Van de Walle, 2019). This approach involves providing a learning environment for students to explore mathematical problems individually or cooperatively to discover ways to solve a problem. Van de Walle and

colleagues (2019) describe teaching *through* problem-solving as being "upside down from teaching *for* problem-solving" (p. 34). That is, the problem is presented at the start of the lesson, and related mathematical knowledge or skill emerges from the exploration. Importantly, in this pedagogy the process of solving problems is completely connected with learning; students are learning mathematics by doing mathematics, and by doing mathematics they are learning mathematics (Cai, 2010). Teaching *through* problem-solving is what it means to learn and *do mathematics*.

Teaching *through* problem-solving is anchored in constructivist theory, which explains that knowledge must be constructed by the learner and cannot be supplied by the teacher. Constructivist theory posits that people construct knowledge through their experiences and interactions with the world (Schunk, 2020). The constructivist view emphasizes that learning happens through experience and not through telling or showing. This theory is rooted in Jean Piaget's work in the 1930s. Piaget's constructivist theory explains how people acquire knowledge, and that new knowledge is neither passively passed from teacher to student nor by students memorizing facts or using tricks and riddles. Rather knowledge is acquired through interactions and connections between existing knowledge and new knowledge (von Glasersfeld, 1989). Like constructivism is the sociocultural theory in which the next component of CREPS pedagogy is grounded.

Culturally Responsive Pedagogy

Culturally responsive pedagogy is based on the premise that cognitive development is mediated using culturally constructed practices, tools, and symbols (Vygotsky, 1978). The sociocultural theory emerged from Lev Vygotsky, a Russian psychologist in the 1930s. Although it is like constructivism, Vygotsky places more emphasis on the social environment as a

facilitator of development and learning (Schunk, 2020). He believed that interactions with a teacher or peer enable a learner to advance through their zone of proximal development, which is the gap between what a learner can achieve by themselves and what they could achieve with the interactions with others.

There are several frameworks in the field of cultural diversity and education that exist for culturally responsive approaches, such as, culturally responsive education, culturally relevant pedagogy, culturally congruent pedagogy, and culturally responsive teaching. Culturally Responsive Pedagogy (CRP) is a framework that can be viewed as an umbrella that encompasses successful pedagogical practices for Black children. CRP uses “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” (Gay, 2018, p. 36). Decades of research and analysis provide a wide range of contributions to the field of CRP. Therefore, it is not possible to capture its entire history. However, discussing the seminal work of the prominent scholar, Gloria Ladson-Billings is necessary to understand how CRP evolved.

Over 20 years ago, Gloria Ladson-Billings introduced the phrase culturally relevant pedagogy, which she describes as a form of teaching that engages learners whose experiences and cultures are traditionally excluded from regular education settings. Based on her research on effective teachers of Black students, Ladson-Billings (1995a, 1995b) proposed three characteristics of these teachers' instruction. First, teaching must yield academic success. Academic achievement is at the center of teaching and learning and requires a teacher to believe that all children can be successful academically, encouraging students to choose academic excellence. Second, teaching must help students develop and/or maintain cultural competence. Cultural competence involves the ability to understand, appreciate, and interact with people from

cultures different from their own as well as their own culture. Third, teaching must support students' development of a critical consciousness through which they challenge the status quo of the current social order. Critical consciousness involves developing students' ability to recognize and analyze systems of inequality and the commitment to act against these systems (Ladson-Billings, 1995a, 1995b, 2014). By making these characteristics visual in their practice, culturally relevant teachers can equip students intellectually, socially, emotionally, and politically.

Building on Ladson-Billings' research, Geneva Gay's framework focused on the strategies and practices that teachers use. In 2000, Gay introduced CRP, which she describes as an approach that stresses "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" (Gay, 2018, p. 36). CRP focuses on incorporating the lives, perspectives, and points of view of students' backgrounds into the teaching and learning. Gay requested that teachers make positive multifaceted changes that include instructional techniques and strategies, instructional materials, student-teacher relationships, classroom climate, and self-awareness to improve learning for Black students. Like Ladson-Billings, Gay promoted teachers providing opportunities for students to think critically about inequities in their own or their peers' experiences.

Both culturally relevant pedagogy and culturally responsive teaching were developed in response to the educational disadvantages experienced by Black students and other minoritized groups. While these frameworks are not identical, they have a common goal to confront the deficit model, which is a perspective which attributes failures to a personal lack of effort or deficiency in the individual, rather than to failure or limitations of the education and training system (Deficit model, 2022). For this conceptual framework, I will use Gay's CRP framework

as it highlights differentiated instruction to accommodate learning that fits every aspect of a students' culture. CRP comprises the following teaching practices: (a) developing knowledge about cultural diversity; (b) including ethnic and culturally diverse curricular content; (c) demonstrating caring and building learning community; (d) implementing cross-cultural communication; and (e) responding to ethnic diversity during instruction (Gay, 2002). Each teaching practice is defined in Table 3.

Table 3.

Culturally Responsive Pedagogy Practices

CRP Practices	Descriptions
Developing knowledge about cultural diversity	Teachers must obtain detailed information about the cultural characteristics of a particular ethnic group to expand their knowledge of other groups.
Including ethnic and culturally diverse curricular content	Teachers must determine the multicultural strengths and weaknesses of curriculum designs and instructional materials and make the changes necessary to improve their overall quality.
Creating a classroom climate conducive to learning	Teachers must demonstrate culturally sensitive caring and build culturally responsive learning communities.
Implementing cross-cultural communication	Teachers must be cognizant of differences in communication styles between students as well as implement practices that are supportive of these differences. Teachers should create learning environments that appreciate and support students' communicative styles to not intellectually silence students.
Responding to ethnic diversity during instruction	Teachers must understand that learning styles are how individuals engage in the process of learning, not their intellectual ability. Students' differences and learning styles should not be viewed as deficiencies. Teachers must challenge the perception that differences among students are problems rather than resources.

Note: Adapted from Gay, G. (2002). Preparing for culturally responsive teaching. *Journal of teacher education*, *53*(2), 106-116. https://doi.org/10.1177/0022487102053002003

Developing knowledge about cultural diversity is the first practice of culturally responsive teaching. Understanding the diversity of ethnicities is one aspect of this knowledge

Gay, 2002). There are many aspects of culture that teachers must understand because they directly affect teaching and learning. Teachers need to know, for example, (a) which ethnic groups prefer communal living and cooperative problem solving and how those preferences affect educational motivations, aspirations, and task performance; (b) how different ethnic groups protocols appropriate ways for children to interact with adults in instructional settings; and (c) how gender role socialization affects how equity initiatives are implemented (Gay, 2002). Another aspect that Gay (2002) describes is teachers obtaining "detailed factual information about the cultural particularities of specific ethnic groups" (p. 107). Instead of having a superficial image or understanding of a group's culture, teachers can gain a deeper understanding of that group.

Another practice of culturally responsive teaching is including ethnic and culturally diverse curricular content. Teachers have to get over the idea that their subjects are incompatible with cultural diversity, or that combining them would be too difficult conceptually and practically (Gay 2002). Making curricula culturally relevant does not devalue the content that is taught in the classroom; rather it connects content to students' cultural experiences to allow for a meaningful learning experience. According to Gay, there are three kinds of classroom curricula, each of which offers a different way of teaching diversity. The first type of classroom curricula is formal curriculum in the form of adopted standards and textbooks. Teachers must determine the multicultural strengths and weaknesses of these instructional materials and make the changes necessary to improve their overall quality. The second type of classroom curricula is symbolic curriculum in the form of visuals like bulletin boards decorations or publicly displayed statements of social etiquette, rules and regulations. The symbolic curriculum can be a powerful tool used by teachers to convey important information, values, and actions for cultural and ethnic

diversity to students. The last type of classroom curricula is societal curriculum which is in the form of how ethnic groups and experiences are presented in mass media and popular culture. Teachers need to understand how media images of ethics groups are manipulated, how they affect ethnic groups, what school curriculum and instruction can do to counteract their effects, and how to teach students to discern and resist ethnic information disseminated through the societal curriculum (Gay, 2002).

Creating a classroom climate conducive to learning is the third practice of culturally responsive teaching. Gay (2002) stated that creating this learning environment "begins by demonstrating culturally sensitive caring and building culturally responsive learning communities" (p. 109). When teachers show culturally responsive caring, they have high expectations and use creative strategies to ensure academic success for ethnically diverse students. To build culturally responsive learning communities, teachers must understand how conflicting work styles may interfere with learning and use that knowledge to design more communal learning environments.

Implementing cross-cultural communication is the next practice of culturally responsive teaching. Gay (2002) noted teachers are taught that "the communication styles of different ethnic groups reflect cultural values and shape learning behaviors and how to modify classroom interactions to better accommodate them" (p. 111). Students have different communication styles, so teachers must be cognizant of these differences and implement practices that support them. Gay adds that "the communicative styles of most ethnic groups of color in the United States are more active, participatory, dialectic, and multimodal" (p. 111). In the classroom, this style of communication can be problematic for both teachers and students because it can be viewed as rude, distractive, and inappropriate to teachers that do not understand these

communication differences. Therefore, to prevent intellectually silent students, teachers should create learning environments that support and appreciate their communication styles.

The last practice of culturally responsive teaching is the actual delivery of instruction to ethnically diverse students. One way of thinking about this idea is matching instructional techniques to the learning styles of diverse students. Gay (2002) recommends that teachers understand that "learning styles are how individuals engage in the process of learning, not their intellectual abilities" (p. 113). The differences and learning styles of students should not be viewed as deficiencies. Teachers must challenge the perception that differences among students are problems rather than resources. Gay (2002) suggested instructional practices such as learning in cooperative groups and peer coaching. Teachers need to develop rich multicultural teaching strategies to teach ethnically diverse students.

Equity-Oriented Pedagogy in Mathematics Classrooms

CRP has extended into various educational fields, such as mathematics. There are growing achievement gaps among Black students and their white peers, especially in mathematics. Developing equity-oriented pedagogy is a response to a need for culture to be addressed in the mathematics classroom. Table 4 highlights two of these models.

Table 4.

Models of Equity-Oriented Pedagogy for Mathematics Classrooms

Model	Name(s) of Scholar (Year)	Tenets of the Model
Dimensions of Equity	Gutiérrez (2012)	Access, Achievement, Identity, and Power
Equity Based Practices in Mathematics Classrooms	Aguirre, Mayfield-Ingram, and Martin (2013)	Going Deep with Mathematics Leveraging Multiple Mathematical Competencies Affirming Mathematics Learners' Identities Challenging Spaces of Marginality Drawing on Multiple Resources of Knowledge

Gutiérrez (2012) defined equity as “fairness, not sameness” (p. 18), and “the inability to predict mathematics achievement and participation based solely on student characteristics such as race, class, ethnicity, sex, beliefs, and proficiency in the dominant language” (p.19). She elaborated on these definitions by presenting a model that included four dimensions: access, achievement, identity, and power. Students should have access to high-quality mathematics, achieve a high standard of academic outcomes, and have opportunities to be and better themselves. The final piece of the model includes power in terms of having a voice in the classroom, having opportunities for students to use math to critique society, having alternative notions of knowledge, and recognizing that math needs people and not just people need math.

Aguirre and colleagues (2013) described a model consisting of five equity-based instructional practices designed to strengthen mathematics learning and positive mathematics identity. Their model includes going deep with mathematics, leveraging multiple mathematical competencies, affirming mathematics learners’ identities, challenging spaces of marginality, and drawing on multiple resources of knowledge. Aguirre and colleagues’ (2013) five equity-based instructional practices in mathematics classrooms will be the model used to articulate as a component of the conceptual framework. The reason for including Aguirre and colleagues (2013) five equity-based practices into CREPS pedagogy is because of its clarity and specificity (see Table 5). A pedagogy that is inclusive of these five equity-based practices in mathematics classrooms has potential to enhance mathematics learning opportunities for Black children, conveys high expectations as outlined by NCTM, and aligns with characteristics of CRP.

Table 5.

Tenets of Equity-Based Practices in the Mathematics Classroom

Equity-Based Practice Tenets	Description of a representative lesson

Going Deep with Mathematics	● Supports students in analyzing, comparing, justifying, and proving their solutions. ● Engages students in frequent debates. ● Presents tasks that have high cognitive demand and include multiple solutio strategies and representations.
Leveraging Multiple Mathematical Competencies	● Structures student collaboration to use varying math knowledge and skills to solve complex problems. ● Presents tasks that offer multiple entry points, allowing students with varying skills, knowledge, and levels of confidence to engage with the problem and make valuable contributions.
Affirming Mathematics Learners' Identities	● Promotes student persistence and reasoning during problem solving. ● Encourages students to see themselves as confident problem solvers who can make valuable mathematical contributions. ● Assumes that mistakes and incorrect answers are sources of learning. ● Validates students' knowledge and experiences as math learners. ● Recognizes mathematical identities as multifaceted, with contributions of various kinds illustrating competence.
Challenging Spaces of Marginality	● Centers student authentic experiences and knowledge as legitimate intellectual spaces for investigation of mathematical ideas. ● Positions students as sources of expertise for solving complex mathematical problems and generating math-based questions to probe a specific issue or situation. ● Distributes mathematics authority and presents it as interconnected among students, teachers, and text. ● Encourages student-to-student interaction and broad-based participation.
Drawing on Multiple Resources of Knowledge	● Makes intentional connections to multiple knowledge resources to support mathematics learning. ● Uses previous mathematics knowledge as a bridge to promote new mathematics understanding. ● Taps mathematics knowledge and experiences related to students' culture, community, family, and history as resources. ● Recognizes and strengthens multiple language forms, including connections between math language and everyday language. ● Affirms and supports multilingualism.

Note: Adapted from Aguirre et al. (2013). *The impact of identity in K-8 Mathematics Learning and Teaching: Rethinking equity-based practices*. The National Council of Teachers of Mathematics, Inc.

Aguirre and colleagues (2013) noted that the first equity-based mathematics is developing a deep understanding of mathematics. This practice involves teachers providing lessons or tasks that have high cognitive demand which support students in analyzing, comparing, justifying, and proving their solutions. Shallow mathematics instruction that focuses

on rote skills, memorization without examination, following procedures step by step, and completing tasks that have low cognitive demand is one of the primary ways students receive inequitable instruction and widens the opportunity gap between Black and white mathematics learners. The current mathematics standards emphasize the importance of students' understanding of the concepts behind the calculations they perform, as well as their productive engagement in mathematical practices, like explanations and justifications (NCTM, 2000). These qualities provide highly engaged mathematics lessons which communicate high expectations for students as well as push teachers to not succumb to deficiency perspectives of diverse learners.

Leveraging multiple mathematical competencies is another equity-based mathematics practice. Aguirre and colleagues (2013) described leveraging multiple mathematical competencies as teachers providing classroom structures that support student collaboration on tasks that offer multiple entry points. In addition, it is described as teachers allowing students with varying ability, knowledge, and levels of confidence to engage with the problem and make valuable contributions. Mathematics instruction that encourages individual progress, promotes group work that is structured by the student's ability level, or requires students to show skill mastery before engaging in complex problem solving is another way students receive inequitable instruction. Research proclaims that students' achievement drastically improves when students have opportunities to collaborate (Kagan & Kagan, 2010; Smith and Stein, 2018), especially in mathematics, which helps students interpret and discuss math in a judgment-free zone. Cooperative learning is important in demonstrating positive effects of interdependence and personal accountability amongst students, making them feel valued.

Affirming mathematics learners' identities is the third equity-based mathematics practice. Aguirre and colleagues (2013) described affirming mathematics learners' identities as instruction

that encourages students to view themselves as confident problem solvers who can make valuable contributions to the mathematics being learned by explicitly validating students' knowledge and experiences as learners of mathematics. Additionally, it provides focused feedback on making sense of the mathematical ideas rather than on the correct answers by using mistakes and incorrect answers as sources of learning. Mathematics instruction that connects mathematical identity solely with correct answers, explicitly discourages mistakes and immediately corrects them, without constructive feedback and given ambivalent value to flexibility, reasoning, and persistence is a way students receive inequitable instruction. NCTM (2020) advocates for fostering students' positive mathematical identities by broadening the purpose of learning mathematics and implementing equitable mathematics instruction so every student sees themselves as doers of mathematics. Recognizing and including students' mathematical identities in instruction validates their learning by positively reflecting students' cultures and communities in a nontrivial way.

Challenging spaces of marginality is the next equity-based mathematics practice. Aguirre, and colleagues (2013) described challenging spaces of marginality as centering student authentic experiences and knowledge as legitimate intellectual spaces for investigation of mathematical ideas, such as structuring student participation and work that promotes use of drawing or multiple representations to exhibit mathematical thinking. Traditional mathematics instruction that focuses on lectures and seatwork makes students feel marginalized, ignored, or positioned as dumb, which causes students to be unsuccessful. Researchers believe that cultivating mathematical proficiency requires an instructional approach that embraces students' mathematical competencies, diminishes status, and values multiple mathematical contributions (Aguirre et al., 2012; Aguirre et al., 2013). This practice encourages teachers to provide lessons

that allow students to reflect on the larger social realities that Black students experience, such as racial profiling.

Drawing on multiple resources of knowledge is the last equity-based mathematics practice. Aguirre, and colleagues (2013) described drawing on multiple resources of knowledge as using students' previous mathematics knowledge as a bridge to promote new mathematics understanding and making connections to the students' everyday lives such as their culture, language, family, and community. Mathematics instruction that treats previous math knowledge irrelevant and prevents connection to experiences of students is a way students receive inequitable instruction. To ensure that students truly understand and make sense of mathematics, instruction should include experiences that provide students with regular opportunities to make connections to previously learned math and to real life (NCTM, 2020). Intentional connections to multiple resources of knowledge helps students gain a better understanding about diverse groups.

An equity informed pedagogy, such as CREPS pedagogy in a mathematics classroom would likely enhance teacher awareness of cultural inconsistencies that feed achievement gaps. I assert that an equity informed pedagogy provides increased awareness of learners that may afford more opportunities to learn as well as appropriate interventions. Equity-based mathematics practices are rooted in critical pedagogy, which is a perspective that acknowledges the effects that poor education has on oppressing impoverished people. Critical pedagogy is connected to critical theory, which involves becoming aware of and questioning existing conditions. Vossoughi and Gutiérrez (2017) noted that critical pedagogy is a multi-voiced field and movement that analyzes the relationship between education and oppression to help bring about social transformation. Paulo Freire, a Brazilian educator, is known as the father of critical pedagogy (Kirylo, 2013). Freire criticizes what he terms the “banking” model of education,

which sees students as passive, empty vessels to be filled by knowledgeable teachers. He stressed that teaching is more than seeking to transfer knowledge into passive students. He linked this model of education to the socio-economic and political relationship between oppressor and the oppressed which he experienced firsthand as a young child during his years of poverty and hunger. In critical pedagogy, a teacher uses his or her own enlightenment to encourage students to question and challenge inequalities that exist in families, schools, and societies. It emphasizes the role of educators to teach students to think about social injustices, so they can improve the world in which they live.

Culturally Responsive Equitable Problem-Solving Pedagogy

The CREPS pedagogy exists at the intersection of CRP, equity-oriented practices, and teaching through problem solving. Informed by these three theories, the CREPS pedagogy was conceptualized as three pedagogical moves -- development of deep mathematics understanding, acknowledgement of students' cultures and employment of equitable pedagogical practices -- with expectations for teachers and lessons (see Table #).

Table 6.

Pedagogical Tenets of the CREPS Pedagogy

Pedagogical Tenets	Math Teachers should …	Math Lessons should …
Development of Deep Mathematical Understanding	• Recognize that cultural diversity and mathematics are compatible (CRP) • Recognize students' diverse ways of knowing and strengths for mathematics learning and peer support (CRP & EBMP) • Select high-cognitive demand tasks and adapt for student interests or enhanced engagement (EBMP & T*t*PS) • Elicit and use evidence of student thinking (T*t*PS) • Use and connect mathematical representations (T*t*PS)	• Establish clear mathematics goals to focus learning (T*t*PS) • Use rich mathematical tasks that promote: (T*t*PS & EBMP) ○ high cognitive demand ○ multiple entry points, solution strategies and/or exit points ○ multiple representations ○ require explanation, justification or proof ○ authentic solution approaches • Afford productive struggle to learn mathematics (T*t*PS) • Develop mathematical connections and deeper conceptual or procedural understanding (T*t*PS)
Acknowledgement of Students' Culture	• Recognize and acquire information about students' culture (CRP & EBMP) • Recognize and situate students' various mathematical ways of knowing (T*t*PS & EBMP) • Encourage students to see themselves as confident problem solvers (EBMP & T*t*PS)	• Incorporate students' experiences or relevant contexts (EBMP) • Incorporate students' identities, cultures and mathematical backgrounds (CRP & EBMP) • Make connections to cultural practices (e.g., dance, music, movement, etc.) (CRP & EBMP)
Employment of equitable pedagogical practices	• Create classroom climates that foster high expectations for ALL students (CRP & EBMP) • Create collaborative classroom environment (CRP, T*t*PS & EBMP) • Pose purposeful and probing questions (T*t*PS)	• Promote collaborative and collective sense-making (CRP, T*t*PS & EBMP) • Facilitate meaningful mathematical discourse among all learners (i.e., peers and teachers) (CRP, T*t*PS & EBMP)

Culturally Responsive Pedagogy (CRP), Teaching *through* Problem-Solving (T*t*PS), Equity-Based Mathematics Practices (EBMP)

Implications of CREPS Pedagogy for Mathematics Teaching

The mathematics community has been trying for years to improve mathematics learning for all learners, especially Black children, with little success. The CREPS pedagogy offers a way for understanding mathematics instruction by focusing on problem-solving. I therefore assert that it will benefit Black children. The CREPS pedagogy requires teachers to develop a deep understanding of the underlying theories of CRP, EBMP, and T*t*PS. This can be achieved by engaging them in each of these pedagogical approaches through professional learning. Research conducted over the past few decades has shown that to alter instruction and enhance student learning, it requires a consistent investment of time in teacher professional learning (Darling-Hammond et al., 2017). In doing so, teachers should be engaged in rich mathematical tasks to help strengthen their own mathematical problem-solving understanding. In addition, professional learning should include teachers engaging in collaborative learning through short cycles of iterative teaching, such as lesson study. Lesson study, a collaborative, practice-based cycle of inquiry that centers around study, planning, observation, and analysis of actual classroom lessons (Takahashi et. al., 2013), possesses the characteristics of effective professional development. I assert further that if we approach professional learning in this way, that teachers will be more ready to implement the CREPS pedagogy.

Recommendations for Future Research

Because CREPS pedagogy is an original conception, designed by a Black scholar for Black children, there are several opportunities for further research. For example, there is a need to explore the fidelity of the CREPS pedagogy conceptualization that emerged from this synthesis of CRP (Gay, 2002), equity-oriented practices (Aguirre et al., 2013), and teaching *through* problem solving (Schroeder & Lester, 1989). Potential research questions to consider:

What is the CREPS pedagogy missing for effectively engaging Black mathematics learners? What aspect, if any, of the CREPS pedagogy has been undertheorized? To support teachers' adoption of CREPS pedagogy for mathematics teaching will require affording them opportunities to engage in professional learning involving collaborative and practice-centered experiences (Akiba et al, 2019; Dudley et al., 2019; Murata et al., 2012; Takahashi et al., 2013). A recommendation for developing teachers' CREPS pedagogical knowledge is to afford them opportunities to participate in engaging in CREPS pedagogy as learners to introduce the CREPS pedagogy. Additionally, teachers would likely benefit from engaging in professional learning that includes collaborative and iterative teaching experiments using CREPS pedagogy. For example, teachers' implementation of CREPS pedagogy using lesson study would afford teachers and researchers insights about both teachers' and students' experiences in relation to mathematics learning. Potential research questions might include: What is the nature of Black learners' mathematics engagement and discourse during a CREPS pedagogy lesson? What types of questions were posed during a CREPS pedagogy lesson and how do they compare to other mathematics lessons? Lastly, it is recommended that further research examine the academic outcomes of Black students when their teachers effectively teach mathematics using CREPS pedagogy. These recommendations for further research are just the tip of the iceberg of investigation into the CREPS pedagogy.

Conclusions

A major concern in the mathematics education research community is the persistence of and how to diminish the achievement gap between Black and white students. As the United States continues to become increasingly more culturally diverse, this gap over time has continued to persist. Research in education aims to find a way to teach all students no matter their culture,

ethnicity or race. I assert that mathematics education researchers interested in studying teaching practices that help Black students begin from Martin's (2019) standpoint of Black learners' brilliance coupled with a framework conceptualized for Black students. I offer the CREPS pedagogy, my theoretical conceptualization that connects black culture, equity, and mathematical problem-solving.

CHAPTER 3

ESSAY 2 – DEVELOPING CULTURALLY RESPONSIVE EQUITABLE PROBLEM-SOLVING PEDAGOGICAL KNOWLEDGE

In today's world, as teachers enter the teaching profession, they should prepare to effectively engage all students, and in the United States many schools are becoming more culturally diverse. Because of this, much research has been conducted surrounding the educational needs of culturally diverse students (e.g., Atwater, Russell, & Butler, 2014; Aguirre, Mayfield-Ingram & Martin, 2013; Aguirre et. al., 2017; Confrey, 2010; Martin et.al., 2010; Martin, 2013, 2019; Sleeter, 2001, 2008). Despite the pedagogical importance of culturally responsive teaching, these practices are not commonly implemented in many classrooms. Many teachers continue to rely on more traditional curricula and methods of teaching. Martin et al. (2019) argue that the traditional practices and norms upheld in mathematics classrooms are often consistent with white cultural norms, which are assumed to be the standard and guide the way that mathematics is taught and valued.

The purpose of this research is to explore ideas of how to improve Black students' opportunities to engage in effective mathematical problem solving to improve their mathematics understanding and achievement. This essay aims to understand whether teachers believed they were ready to teach in a culturally responsive way and to capture teachers' perceptions as they participated in professional development designed to introduce culturally responsive equitable problem-solving pedagogy (CREPS). This study was guided by the research questions below:

RQ1: At what levels do secondary mathematics teachers from a large predominantly Black school district rate their readiness for teaching as measured by the Culturally Responsive Teaching Readiness Scale?

RQ2: How do secondary mathematics teachers from a large predominantly Black school district perceive culturally responsive teaching?

RQ3: How do you prepare secondary mathematics teachers to understand Culturally Responsive Equitable Problem Solving (CREPS) Pedagogy?

The following sections include a discussion of relevant literature and the conceptual framework that was used as a lens for conducting the study. The next section will describe the methodology used to conduct the study. After that, the research results are presented, followed by an interpretation of the findings in the discussion section.

Literature Review

The goal of this literature review is to synthesize existing literature about the readiness level of teachers for culturally responsive teaching and their perceptions of culturally responsive teaching. In addition, this section includes a discussion of the conceptual framework, Culturally Responsive Equitable Problem-Solving (CREPS) pedagogy, used as a lens for conducting this study. This section will conclude with a summary of why this study is important, and how it will contribute to the literature.

Teachers' Culturally Responsive Teaching Readiness

Recent research has shown that teachers' readiness plays a role in understanding and enacting CRP. Several researchers have used the Culturally Responsive Teaching Readiness Scale (CRTRS) to measure teachers' readiness of CRP (e.g., Moore et al., 2021; Özüdoğru, 2018; Zorba, 2020). Özüdoğru (2018) explored the readiness level of 403 preservice teachers and found that they felt highly ready for CRP. In a quantitative study involving 36 preservice teachers, Moore et al. (2021) found a relatively high mean overall with little variation and a statistically significant difference between personal and professional readiness. Unlike Moore et

al. (2021) and Özüdoğru (2018) who studied preservice teachers, Zorba (2020) employed a sample of in-service teachers but similarly found a significant difference between personal and professional readiness. In this study, the CRTRS will be used to measure the CRP readiness of in-service secondary mathematics teachers.

Teachers Perceptions about Culturally Responsive Pedagogy

Recent research has shown that teachers perceive culturally responsive teaching as being an important factor when teaching in culturally diverse classrooms (e.g., Bonner et al., 2018; Mette, 2016; Nash, 2018; Navarro et al., 2022; Samuels, 2018). In Bonner and colleagues' study, 430 P-12 urban teachers shared positive perceptions towards cultural diversity. These teachers viewed culturally responsive teaching as an asset, had a strong sense of efficacy, and felt competent to teach diverse students. Although many teacher candidates study culturally responsive teaching theories during their initial teacher certification programs, Samuels (2018) found many teachers feel less confident implementing culturally responsive teaching in their own classrooms. Another study examined culturally responsive teaching perceptions of teacher candidates of color and found that they felt the undergraduate program was “promising yet fleeting, missing the mark, and was a misuse of culture and language that resulted in harm” (Navarro et al., 2022, p. 374).

Researchers have suggested that more research be conducted on the impact of professional learning on teachers' understanding and perceptions of culturally responsive teaching (e.g., Ebersole et al., 2015; Karatas & Oral, 2015; McKoy et al., 2017). McKoy et al. (2017) investigated the impact of an in-service program on teachers’ perceptions of culturally responsive teaching. The participants reported an increase in feelings of familiarity and understanding of the importance of culturally responsive teaching higher than they did prior to

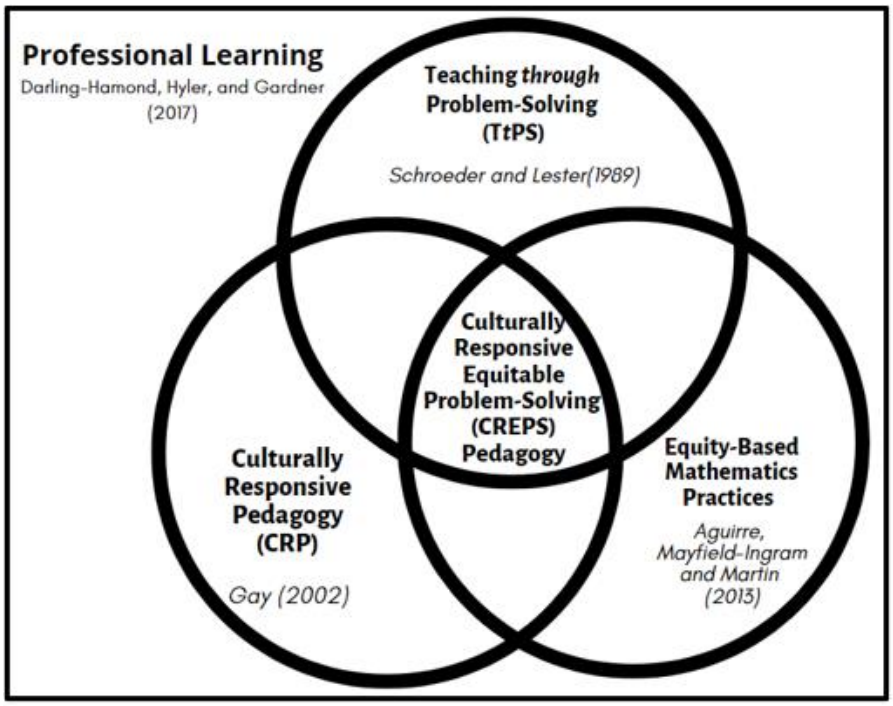
the workshop. Similarly, Karatas and Oral (2015) concluded that training or courses related to culturally responsive teaching positively affected teachers' perceptions and their attitudes towards instruction to culturally diverse students. In addition, Ebersole and colleagues' (2015) study concluded that the professional development sessions resulted in an increase of culturally responsive practices, but teachers reported that they were not always able to distinguish between being a culturally responsive teacher and doing culturally diverse activities. Given these findings, this study will address how in-service secondary mathematics teachers conceptualize and prepare them to use culturally responsive equitable problem-solving pedagogy.

Conceptual Framework

The CREPS pedagogy (see Figure 2) is an asset-based framework used to examine problem-solving teaching practices of mathematics teachers of Black students. The CREPS pedagogy is a synthesis of three pedagogical ideas: Gay's (2002, 2010, 2018) Culturally Responsive Pedagogy (CRP), Aguirre, Mayfield-Ingram, Martin's (2013) Equity-Based Mathematics Practices, and Schroeder and Lester's (1989) Teaching *through* Problem-Solving (T*t*PS). When these pedagogies are merged and situated within professional learning, they make a powerful combination for teaching mathematical problem-solving to all students, including Black students.

Figure 2.

A Framework for Developing the CREPS Pedagogy Situated within Professional Learning



Given that the CREPS pedagogy suggests that Black students will succeed in mathematics if their lives, perspectives, and points of view are incorporated into teaching, the CREPS pedagogy borrows from Gay's (2018) Culturally Responsive Pedagogy (CRP) literature. CRP is a framework that can be viewed as an umbrella of pedagogies that encompasses successful teaching approaches for Black children. For the CREPS pedagogy framework, CRP is "using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching them more effectively" (Gay. 2010, p. 31). CRP comprises the following teaching practices: (a) developing a knowledge base about cultural diversity; (b) including ethnic and cultural diversity content in the curriculum; (c) demonstrating caring and building learning communities; (d) implementing cross-cultural communications; and (e) responding to ethnic

diversity in the delivery of instruction (Gay, 2002, 2010, 2018). Each teaching practice is defined in Table 7.

Table 7.

Culturally Responsive Pedagogy Practices

CRP Practices	Descriptions
Developing a knowledge base about cultural diversity	Teachers must obtain detailed information about the cultural characteristics of a particular nation to expand their knowledge of other groups. Instead of having a superficial image or understanding of a group's culture, teachers can gain a deeper understanding of that group.
Including ethnic and cultural diversity content in the curriculum	Teachers must be willing to overcome the idea that their subjects and cultural diversity are incompatible, or that combining them is too much of a conceptual and substantive stretch for their subjects to maintain disciplinary integrity.
Demonstrating caring and building learning communities	Teachers must determine the multicultural strengths and weaknesses of curriculum designs and instructional materials and make the changes necessary to improve their overall quality.
Implementing cross-cultural communications	Teachers must be cognizant of differences in communication styles between students as well as implement practices that are supportive of these differences. Teachers should create learning environments that appreciate and support students' communicative styles to not intellectually silent students.
Responding to ethnic diversity in the delivery of instruction	Teachers must understand that learning styles are how individuals engage in the process of learning, not their intellectual ability. Students' differences and learning styles should not be viewed as deficiencies. Teachers must challenge the perception that differences among students are problems rather than resources.

Note: Adapted from Gay, G. (2002). Preparing for culturally responsive teaching. *Journal of Teacher Education*, 53(2), 106–116. https://doi.org/10.1177/0022487102053002003

In addition, the CREPS pedagogy suggests that Black students will succeed in mathematics if teachers ensure equal access, opportunities, and outcomes for all students, regardless of their backgrounds, abilities, or identities. Thus, the CREPS pedagogy leverages equity-based mathematics teaching pedagogy, that is, "a model consisting of five equity-based instructional practices designed to strengthen mathematics learning and positive mathematics

identity" (Aguirre et al., 2013, p. 43). The five equity-based pedagogical tenets include: (a) going deep with mathematics; (b) leveraging multiple mathematical competencies; (c) affirming mathematics learners' identities; (d) challenging spaces of marginality; and (e) drawing on multiple resources of knowledge (for descriptions see Table 8).

Table 8.

Tenets of Equity-Based Practices in the Mathematics Classroom

Equity-Based Practice Tenets	Description of a representative lesson
Going Deep with Mathematics	● Supports students in analyzing, comparing, justifying, and proving their solutions. ● Engages students in frequent debates. ● Presents tasks that have high cognitive demand and include multiple solution strategies and representations.
Leveraging Multiple Mathematical Competencies	● Structures student collaboration to use varying math knowledge and skills to solve complex problems. ● Presents tasks that offer multiple entry points, allowing students with varying skills, knowledge, and levels of confidence to engage with the problem and make valuable contributions.
Affirming Mathematics Learners' Identities	● Promotes student persistence and reasoning during problem solving. ● Encourages students to see themselves as confident problem solvers who can make valuable mathematical contributions. ● Assumes that mistakes and incorrect answers are sources of learning. ● Validates students' knowledge and experiences as math learners. ● Recognizes mathematical identities as multifaceted, with contributions of various kinds illustrating competence.
Challenging Spaces of Marginality	● Centers student authentic experiences and knowledge as legitimate intellectual spaces for investigation of mathematical ideas. ● Positions students as sources of expertise for solving complex mathematical problems and generating math-based questions to probe a specific issue or situation. ● Distributes mathematics authority and presents it as interconnected among students, teachers, and text. ● Encourages student-to-student interaction and broad-based participation.
Drawing on Multiple Resources of Knowledge	● Makes intentional connections to multiple knowledge resources to support mathematics learning. ● Uses previous mathematics knowledge as a bridge to promote new mathematics understanding. ● Taps mathematics knowledge and experiences related to students' culture, community, family, and history as resources.

- Recognizes and strengthens multiple language forms, including connections between math language and everyday language.
- Affirms and supports multilingualism.

Note: Adapted from Aguirre et al. (2013). *The impact of identity in K-8 Mathematics Learning and Teaching: Rethinking equity-based practices*. The National Council of Teachers of Mathematics, Inc.

Moreover, all students, including Black students, experience mathematics success when teachers afford them a learning environment where students explore mathematical problems individually or cooperatively and discover their own ways to solve problems. The CREPS pedagogy leverages pedagogy from Schroeder and Lester's (1989) teaching *through* problem-solving (T*t*PS). T*t*PS as a pedagogy of inquiry and exploration has been categorized as a set of eight teaching practices: (1) establish mathematics goals to focus learning; (2) implement tasks that promote reasoning and problem solving; (3) use and connect mathematical representations; (4) facilitate meaningful mathematical discourse; (5) pose purposeful questions; (6) build procedural fluency from conceptual understanding; (7) support productive struggle and learning mathematics; and (8) elicit and use evidence of student thinking (NCTM, 2014) (for descriptions, see Table 9).

Table 9.

Eight Mathematical Teaching Practices that Support Student Learning

Teaching Practice	Description
1. Establish mathematics goals to focus learning	Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.
2. Implement tasks that promote reasoning and problem solving	Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies.
3. Use and connect mathematical representations	Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving.

4. Facilitate meaningful mathematical discourse	Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.
5. Pose purposeful questions	Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sensemaking about important mathematical ideas and relationships.
6. Build procedural fluency from conceptual understanding	Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.
7. Support productive struggle and learning mathematics	Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and supports, to engage in productive struggle as they grapple with mathematical ideas and relationships.
8. Elicit and use evidence of student thinking	Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.

Note: Principles to actions: ensuring mathematical success for all. (2014). Reston, VA: NCTM, National Council of Teachers of Mathematics

At the root of the CREPS pedagogy is the belief that Black students can be successful mathematical problem solvers when teachers implement characteristics of each of the pedagogies - CRP, equity-based mathematics teaching, and T*t*PS. Each pedagogy independently is very effective and contributes important elements to what is considered necessary to provide good mathematics instruction. I am advocating that together they make a more comprehensive pedagogy to support problem-solving in mathematics instruction for students who have been historically marginalized, such as Black students.

Summary

This literature review focused on the research around culturally responsive teaching readiness, teacher perceptions of culturally responsive teaching, and components of the conceptual framework: the CREPS pedagogy. Although several researchers have explored

preservice and in-service teachers' readiness for culturally responsive teaching and perceptions of culturally responsive teaching (e.g., Ebersole et al., 2015; Karatas & Oral, 2015; McKoy et al., 2017; Moore et al., 2021; Özüdoğru, 2018; Zorba, 2020), limitations exist. This essay aimed to understand whether teachers believed they were ready to teach in a culturally responsive way and to capture teachers' perceptions as they participated in professional development designed to introduce the CREPS pedagogy. This study will contribute to the literature regarding shaping and meeting the educational needs of Black students in mathematics.

Methods

In this section, the research methodology used for this research study is described. This study sought to answer the following research questions:

RQ1: At what levels do secondary mathematics teachers rate themselves to be ready for culturally responsive teaching as measured by the Culturally Responsive Teaching Readiness Scale?

RQ2: How do secondary mathematics teachers perceive culturally responsive teaching?

RQ3: How do you prepare secondary mathematics teachers to understand Culturally Responsive Equitable Problem-Solving Pedagogy?

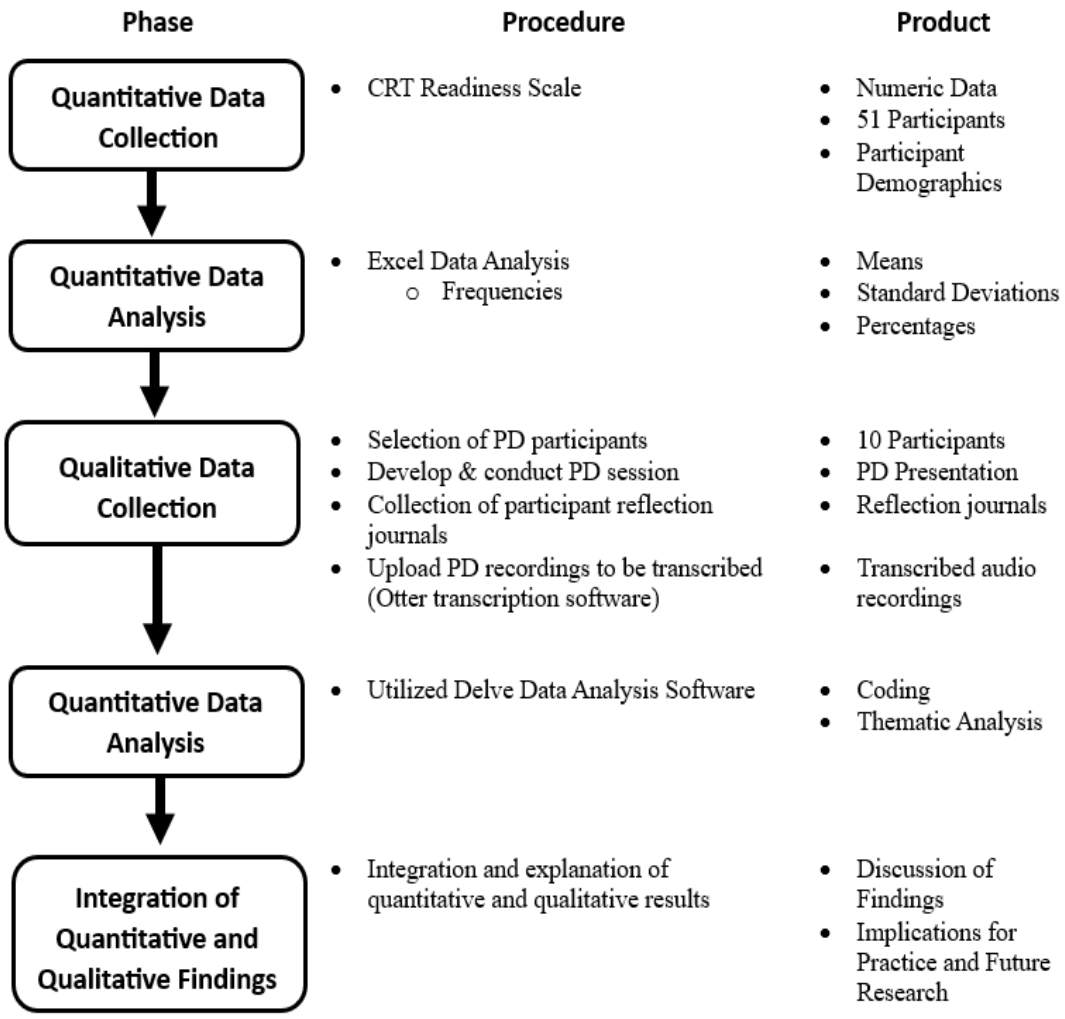
To address the research questions, a survey and a professional development was conducted to capture teachers' perceptions of their readiness for culturally responsive teaching and to prepare them for understanding the CREPS pedagogy. This section begins with an overview of the research design, followed by the research context and a description of the participants. Finally, a detailed account of the data collection procedures and the data analysis process is included.

Research Design

This research study used an explanatory sequential mixed methods design that involves combining quantitative and qualitative research methods (Creswell, 2014). The data is integrated for the purpose of gaining a better understanding of the research questions. Onwuegbuzie and Mallette (2011) explained that the explanatory sequential mixed methods design involves two phases of data collection and analysis. The model of the sequential explanatory mixed methods design is described in Figure 3.

Figure 3.

Model of sequential explanatory mixed methods design



Note: PD stands for Professional Development

During the first phase, the quantitative data was collected and analyzed. Based on the quantitative data results, the qualitative data was gathered to help explain the quantitative findings. The explanatory sequential mixed methods design was useful as the aim of the study was to understand quantitatively whether teachers believed they were ready to teach in a culturally responsive way and to capture the teacher's perceptions qualitatively, as they participate in a professional development positioned as the CREPS pedagogy. A mixed method was also useful as Onwuegbuzie and Mallette argued that mixed methods research provides stronger inferences than using either quantitative or qualitative approaches on its own. The description of the participants, the data collection procedures and the data analysis process will follow.

Research Context

Describing the context in which this study was conducted is crucial because it gives the audience a better understanding of the background of the research (Creswell & Poth, 2018). This study was conducted in a large urban school district located in a southeastern state. The school district has approximately 27,300 students enrolled with 60.9% identified as receiving free or reduced lunch, 14% identified as learning disabled, and 5% are English Language Learners. The student enrollment demographics are found in Table 10.

Table 10.

Student Demographics

Ethnicity	*n*	%
American Indian	92	0.3%
AAPI	574	2.1%
Black	15,576	57.0%
Hispanic	3,654	13.4%
Two or more	1,865	6.8%

White	5,569	20.4%

Note: This data reflects the 2022-2023 school year.

Regarding mathematics student achievement, approximately 46% of the students were proficient on the end of the year state assessments in 2022. Thirty-five percent of Black students were proficient compared to 69% of white students.

Participants

From a list of approximately 2,500 educators teaching at the same urban school district, a pool of secondary mathematics educators was generated. This process yielded a participant pool of 80 teachers. Fifty-one (51) secondary mathematics educators completed the CRTRS. The response rate was 64%. An overview of participant demographics is shown in Table 11.

Table 11.

Participant Demographics (N = 51)

Measure		*n*	*%*
Gender	Female	33	65%
	Male	18	35%
Age	Under 30	7	13.7%
	30 - 49	18	35.3%
	50 and over	26	51%
Teaching Context	Middle School	26	51%
	High School	25	49%
Teaching Experience	10 years and under	20	39.2%
	11 to 20 years	17	33.3%
	Over 20 years	14	27.5%
Race	AAPI	8	15.7%
	Black	23	45.1%
	White	20	39.2%

Note: AAPI stands for Asian American Pacific Islander

Most of the participants were female (N = 33; 65%). A little over half of the participants taught middle school (N = 26; 51%) and represented ages of 50 and over (N = 26; 51%). Teachers of color represented over half of the participants (N = 31; 60.8%) compared to white teachers (N = 20; 39.2%).

Researcher Positionality

Reflexivity refers to researchers "positioning themselves" in a qualitative research study by making their background known, how it informs their interpretation of the data in the study, and what they must gain from the study (Creswell & Poth, 2018). There are many facets that make up the researcher's positionality, most of which embody markers of minority groups. In this research study, the sole researcher is a 50-year-old Black woman, working toward a doctorate in curriculum and instruction in mathematics education. As the sole researcher, I am aware of my positionality and role within this study and understand how my perceptions would affect the study.

I remember being an average performing math student. I was able to understand math when presented with numbers to compute or equations to solve, but I struggled to problem solve. I am currently the senior mathematics coordinator in the school district where this study was conducted. Prior to this position, I was a district mathematics specialist. In both positions, I was tasked with developing curriculum materials that were culturally responsive to help math teachers explore and integrate mathematical problem solving in their math instruction. As the senior coordinator of secondary mathematics, I oversee the district math curriculum and provide professional development for the mathematics teachers in the district. Although my position of senior coordinator is not evaluative, there is a level of legitimate power due to the nature of the

role. It is important to build trust and relationships with teachers, so they do not perceive this power to be negatively impactful.

Before working at the district level, I worked 19 years in the public-school system as a secondary mathematics teacher. As a math teacher, it was difficult to plan and implement culturally responsive mathematical problem-solving strategies effectively in my teaching. I am highly interested in equipping other math teachers with the tools to teach Black students to be mathematical problem solvers. My philosophical background and positionality within my career created an intrinsic desire to learn more about culturally responsive mathematics teaching, specifically for mathematical problem solving. As a math teacher, a district math specialist, and the senior coordinator of secondary mathematics, I constantly endeavor to have culturally responsive mathematical problem-solving teaching incorporated in every math classroom. My role as researcher and my positionality contributed to me providing a deeper understanding about math teachers' experiences with implementing culturally responsive strategies in their math instruction. These struggles, as a math student, math teacher, district math specialist, and senior coordinator of math have led me to question whether others have the same difficulties and whether this is a systemic issue.

Data Collection Procedures and Analysis

In the first, quantitative phase of the study, purposive sampling was used as it will "intentionally sample a group of people that can best inform the researcher about the research problem under examination" (Creswell and Poth, 2018, p. 148). After approval from the institutional review board (see Appendix A) and approval from the school district (see Appendix B), teachers were sent an email invitation (see Appendix C) to participate in this study. Email invitations included a hyperlink to the electronic version of the survey in Qualtrics. Subsequent

emails were sent to mathematics department chairs to re-share study information to teachers that may have been overlooked.

Karatas and Oral's (2017) Culturally Responsive Teaching Readiness Scale (CRTRS) were administered. It was selected to examine whether in-service teachers believed they were ready to implement culturally responsive teaching in their classroom instruction. The disseminated survey included the informed consent (see Appendix D), demographic questions (e.g., gender, race, teaching context) (see Appendix E) and the CRTRS (Karatas & Oral, 2017) (see Appendix F). All survey responses were recorded using the online software, Qualtrics. After completion of the survey, participants were asked to register for a raffle to win one of four $25 Amazon gift cards and indicate their interest in participating in a follow-up professional development.

The CRTRS consists of 21 items designed in a 5-point Likert-type scale, strongly agree to strongly disagree. The scale has two subdivisions: 12 items in the dimension of *Personal Readiness* and nine items in the dimension of *Professional Readiness*. The personal readiness sub-dimension can have scores ranging from 12 to 60 and the professional readiness sub-dimension can have scores ranging from 9 to 45. When evaluating the scores, the total score or the scores from each sub-dimension can be used. Participants who have higher scores on the CRTRS have a high readiness. The scale was proved to be a reliable instrument with .92 Cronbach's Alpha internal consistency coefficient for person readiness subscale and .87 for the professional readiness subscale and .90 for the whole scale.

Descriptive statistics (means and standard deviations) were calculated to test the normal distribution of the data set. Incomplete survey responses were removed. New variables were created to convert from categorical, such as gender (i.e., 1 = female, 2 = male) and teaching

context (i.e., 1 = middle school, 2 = high school). Similarly, all item responses on the CRTRS were categorical, and were coded on a 5-point scale (e.g., 1 = Strongly Disagree, 5 = Strongly Agree). When calculated, the higher the mean the more the participants agreed with the statements. Table 12 includes the range of the mean values for each category.

Table 12.

Descriptions of range of mean values for each category

Category	Range of Mean Values
Strongly Disagree	1.00 - 1.79
Disagree	1.80 - 2.59
Undecided	2.60 - 3.39
Agree	3.40 - 4.19
Strongly Agree	4.20 - 5.00

If the mean was between 1.00 and 1.79 the participants strongly disagreed with the statements and disagreed if the mean was between 1.80 and 2.59. If the mean was between 2.60 and 3.39 the participants were undecided. If the mean was between 3.40 and 4.19 the participants agreed with the given statements and strongly agreed if the mean was between 4.20 and 5.00. When calculated, the higher the standard deviation the more heterogeneous the sample. The lower the standard deviation the more homogenous the sample.

In the second, qualitative phase of the study, stratified purposeful sampling was used. At the completion of the survey, participants were asked if they would like to participate in a professional development session (phase two). Of the 51 participants that completed the survey, 17 elected to participate in the professional development session. They were contacted via email

after the completion of the quantitative data analysis. Of the 17 teachers that said they would participate in the professional development, 10 were able to attend.

In the second phase, the three-hour professional development session was conducted. The professional development focused on the CREPS pedagogy. Before the start of the professional development, participants completed the informed consent (see Appendix G). The participants began by pondering what they thought the term "culturally responsive teaching" meant to them. In addition, they explored what T*t*PS meant. They were led through an activity designed to increase their understanding of high cognitive demand tasks, which is a characteristic of the CREPS pedagogy. Teachers were given several tasks, which varied in their level of cognitive demand – high or low level, to sort. Using their completed sorts, they developed a list of characteristics for each level. Afterwards, they completed a high cognitive demand task collaboratively, which is referred to as a rich mathematical task (RMT) (see Appendix H). Teachers reflected on their experiences as they completed the task. In addition, through prompting, the participants discussed what they thought might be the characteristics of rich mathematical tasks. The remainder of the professional development session then focused on the interconnectedness of CRP, T*t*PS, and equity-based mathematics teaching practices. Teachers completed a jigsaw activity where they learned about the practice areas of CRP. In addition, they learned what type of teacher characteristics are needed to be culturally responsive. Lastly, they discussed the five equity-based mathematics practices. During the professional development session, there will be several sources of data collection: audio taped professional development sessions, researcher field notes, and teachers' reflection notes.

Several strategies were used to increase trustworthiness for this study. To ensure transferability beyond this study, the researcher provided a detailed description of the

demographics of the participants to include meeting the predetermined criteria. In addition, the researcher listened to the audio recordings twice, once to verify the accuracy of the transcripts and another to provide written memos in the margins of the transcripts to ensure credibility. Next, to increase trustworthiness, the researcher triangulated the data by using quantitative and qualitative data to answer the research questions. Lastly, the researcher included a positionality statement to provide ontological authenticity to reveal the researcher's background and current role (Grant & Lincoln, 2021; Milner, 2007).

Qualitative analysis was conducted after the professional development. Data were analyzed using an inductive approach outlined in table 13 to allow for the development of themes (Braun & Clarke, 2006).

Table 13.

Phases of Thematic Analysis

Phase	Description of the process
1. Familiarizing yourself with data	Transcribe data, read and actively observe meanings and patterns that appear in the data.
2. Create initial codes	Create a set of initial codes that represent the meanings and patterns seen in the data.
3. Collate codes with supporting data	Bring together all the excerpts associated with a particular code.
4. Group codes into themes	Collating codes into potential themes, gathering all data relevant to each potential theme.
5. Evaluate and revise themes	Review and revise themes, ensure that each theme has enough data to support them.
6. Write the narrative	Communicate to readers about the validity of the analysis. Tell a coherent story about the data and choose vivid quotes to back up the points.

Note: Braun, V., & Clarke, V., (2006) Using thematic analysis in psychology, Qualitative Research in Psychology, 3:2, 77-101 https://doi.org/10.1191/1478088706qp063oa

Following the approach outlined by Braun and Clarke (2006), the audio recordings of the professional development session were transcribed. Using the transcriptions and teacher reflections, marginal notes were made and used to form initial codes across the data sources using In Vivo coding. In Vivo coding is a form of qualitative data analysis that places emphasis on the actual spoken words of the participants (Saldaña, 2021). After the preliminary coding, the codes were collated with supporting data to form categories. *Table 14* provides a sample data excerpt, the In Vivo codes and the subsequent categories created to illustrate the coding process.

Table 14.

Sample coded data excerpt

Data Excerpt: Being aware that other **people have different experiences** and ways of looking at things and keeping that in mind. Not making assumptions about others and **being aware of how other cultures might approach something**.	
In Vivo Code: People have different experiences **In Vivo Code:** Being aware of how other cultures might approach something	**Category:** Acknowledgement that culture impacts student learning

Categories were then grouped together using patterns to develop themes. The themes were evaluated and revised (Braun and Clarke, 2006). This process led to the development of three overarching themes (see Table 15) related to the research question. Once the overarching themes were formed, the final analysis and write-up of the results was completed.

Table 15.

Grouping of Categories to Develop Overarching Themes

Categories	Overarching Themes
a) Acknowledgement of students' culture b) Development of meaningful relationships with students c) Employment pedagogical practices that infuse cultural diversity.	Establishing the Meaning of the CREPS pedagogy
a) Teachers' original perceptions b) Changes to teachers' perceptions	Navigating an Understanding of the CREPS pedagogy

a) Deepening the Mathematics Content b) Creating Safe Spaces c) Embedding Collaborative Learning Opportunities	Connecting with Components of the CREPS pedagogy

Results

This section will present the results from the study. There were three goals for this study. The first goal was to understand secondary mathematics teachers' perceptions of their readiness for CRP. Another goal was to see if their perceptions of their readiness aligned with their application of CRP during the professional development. The last goal was to determine how to prepare secondary mathematics teachers to understand Culturally Responsive Equitable Problem-Solving Pedagogy (CREPS). The data that was collected consisted of the CRTRS, audio taped professional development sessions, and teachers' discussions and reflection notes during the professional development. The results from the analyses follow.

Results from the CRTRS

Descriptive values of the participants' scores obtained from the CRTRS were presented in Table 16.

Table 16.

Descriptive values of the scores obtained from the CRTRS.

Readiness Items		**SA**	**A**	**U**	**D**	**SD**	$\underline{X}$	**Std**
1.	I am ready to teach in a class where there is cultural diversity.	80%	16%	4%	0%	0%	4.76	0.51
2.	I am curious about the cultural values of the students in my class.	75%	20%	4%	2%	0%	4.67	0.65
3.	I think that while I guide my students' learning, I need to consider their cultural values.	55%	39%	6%	0%	0%	4.49	0.61
4.	I enjoy interacting with people from different cultures.	86%	12%	2%	0%	0%	4.84	0.42

5.	I do not tolerate students in my class to discriminate against each other because of their cultural diversity.	94%	4%	0%	0%	2%	4.88	0.58
6.	I think it would be fun to train in a class where cultural diversity is experienced.	73%	18%	10%	0%	0%	4.63	0.66
7.	My university instructors created awareness of cultural diversity during my undergraduate or graduate education.	27%	27%	25%	10%	10%	3.53	1.26
8.	When cultural diversity is taken into consideration, I can teach anywhere in the United States.	57%	33%	8%	2%	0%	4.45	0.72
9.	I would like to increase the interactions in and out of the classroom by learning vocabulary and sentences from the mother tongues of my non-English native speakers.	45%	24%	29%	0%	2%	4.10	0.95
10.	I think that the compulsory courses I have taken during undergraduate and/or graduate education have contributed to me in terms of sensitivity to cultural values.	24%	37%	14%	12%	14%	3.45	1.33
11.	I find my undergraduate and/or graduate education program sufficient in creating awareness about cultural diversity in the U.S.	22%	27%	25%	14%	12%	3.33	1.28
12.	I think that students should be encouraged to give examples specific to their own culture in the course of the lessons.	43%	33%	20%	2%	2%	4.14	0.93
13.	I think that having training by taking the cultural environment in which the students are brought up into account will increase students' academic achievement.	41%	35%	24%	0%	0%	4.18	0.78
14.	I gained an awareness of the cultural diversity that lives in the geography of the U.S. during my undergraduate and/or graduate education.	27%	25%	24%	12%	12%	3.45	1.32
15.	I obtained information to know different cultures in the US during my undergraduate and/or graduate education.	25%	39%	8%	20%	8%	3.55	1.27
16.	If I have an option, I will teach in a place where people have different cultural characteristics different from my own culture.	29%	39%	27%	4%	0%	3.94	0.85
17.	I believe that our educational system should be structured to reflect the cultural diversity from pre-school to the university.	65%	22%	14%	0%	0%	4.51	0.72

18.	I am aware that students' cultural lives must be used as a means of achieving their learning objectives.	47%	39%	12%	2%	0%	4.31	0.75
19.	I find textbooks taught in undergraduate and/or graduate education courses sufficient in terms of presenting information related to cultural diversity.	8%	22%	29%	31%	10%	2.86	1.10
20.	I think elective courses I have taken in undergraduate and/or graduate education have contributed to me in terms of sensitivity to cultural values.	14%	33%	27%	16%	10%	3.25	1.17
21.	I have gained awareness of cultural diversity thanks to the involvement of education instructors' personal lives and experiences.	37%	29%	18%	10%	6%	3.82	1.20
Total Readiness							**4.06**	**0.91**

Participants' (N = 51) mean overall scores on the CRTRS were relatively high (M = 4.06), which shows that in-service secondary mathematics teachers who participated in the survey perceived themselves as ready to teach in a culturally responsive way. The table indicates the highest mean scores from the Culturally Responsive Teaching Readiness Scale were for item number *"5. I do not tolerate students in my class discriminating against each other because of their cultural diversity"* (M = 4.88) and item *"4. I enjoy interacting with people from different cultures"* (M = 4.84). These are followed by items *"1. I am ready to teach in a class where there is cultural diversity"* (M = 4.76) and item *"2. I am curious about the cultural values of the students in my class"* (M = 4.67). Over 80% of the participants strongly agreed with these items.

There were several items in which the participants answered *"undecided", "disagree",* or *"strongly disagree"*, hence the lower mean scores on the survey. In examining specific items, the lowest mean scores were obtained from items related to the teachers' undergraduate and/or graduate programs, such as item *"19. I find textbooks taught in undergraduate and/or graduate education courses sufficient in terms of presenting information related to cultural diversity"* (M = 2.86), followed by items *"20. I think elective courses I have taken in undergraduate and/or*

graduate education have contributed to me in terms of sensitivity to cultural values" (M = 3.25), and item *"11. I find my undergraduate and/or graduate education program sufficient in creating awareness about cultural diversity in the U.S."* (M = 3.33). Although these items were the lowest or least endorsed, they had mean scores that fell in the undecided range, between 2.60 and 3.39. This suggests that participants had neither a positive nor negative response to the item.

Results from the professional development

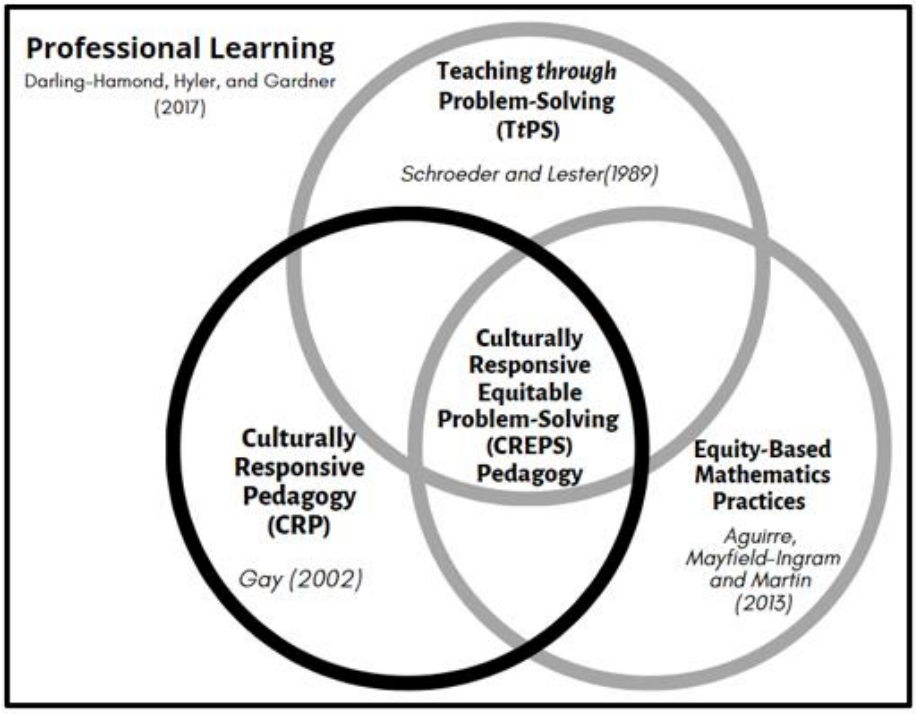
Data collected from the professional development session was used to address research question two, regarding participants' perceptions of the CREPS pedagogy. The data was generated from 10 secondary mathematics teachers who attended the professional development. Three overarching themes emerged from the analyses from the professional development session: (1) establishing a meaning of the CREPS pedagogy, (2) navigating an understanding of the CREPS pedagogy, and (3) connecting with components of the CREPS pedagogy. Following a discussion of the three themes, a summary of the section is presented.

Establishing the meaning of the CREPS pedagogy

The analysis of the survey data revealed that participants found themselves ready to teach in a culturally responsive way. Thus, the professional development session started with participants sharing their perceptions about the meaning of CRP, a construct of the CREPS pedagogy framework (see Figure 4).

Figure 4.

A Framework for Developing the CREPS Pedagogy *Highlighting CRP*



The analysis of patterns from the data revealed that the participating in-service secondary mathematics educators had a multilayered perception of CRP, which produced three sub-themes. Their perceptions included (a) acknowledgement of students' culture, (b) development of meaningful relationships with students, and (c) employment of pedagogical practices that infuse cultural diversity. Each of the sub-themes will be discussed below.

Acknowledgement of students' culture

Professional development participants described the CREPS pedagogy as a pedagogical approach to teaching mathematics that acknowledges the need for teachers to be cognizant of how students' cultures may shape their learning experiences. For example, one participant explained that CRP means *"being aware that other people have different experiences,"* and

"being aware of how other cultures might approach something." Another participant noted that CRP means *"when you recognize students' cultural backgrounds, you are better able to understand how they will view the work."* Furthermore, a participant voiced frustration with how students of different backgrounds have limited opportunities to relate to mathematics when it is taught in a traditional setting. The participant responses suggested that awareness of the students' culture, backgrounds and experiences is a critical aspect of CRP.

Development of meaningful relationships with students

Professional development participants also discussed the development of meaningful relationships with students as an essential part of CRP. A participant emphasized that CRP involves *"finding connections with students and implementing those connections within teaching."* Similarly, another participant noted that CRP should include *"building a positive rapport with students"* and *"showing genuine interest in the students and allowing that interest to guide instruction."* The participant statements suggested that developing meaningful relationships with students is another critical aspect of CRP.

Employment of culturally diverse pedagogical practices

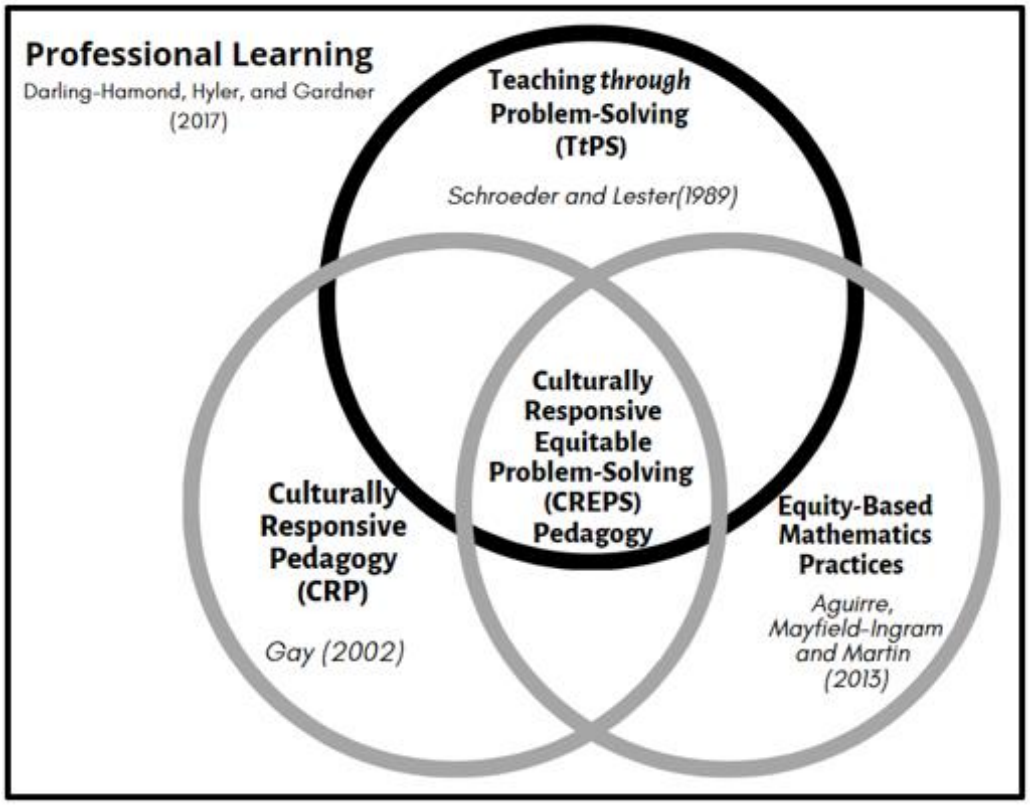
Participants overwhelmingly discussed the importance of employing pedagogical practices that infuse cultural diversity as a definition of CRP. For example, when asked what CRP means to you, one participant responded, *"The first thing that comes to mind is when a teacher provides equitable practices and opportunities to all students."* Another participant noted that *"When developing lessons and activities, looking at your students' backgrounds and interest in creating activities will allow them to interact with the content at a personal level".* In addition, they mentioned that CRP includes *"teaching and meeting students where they are."* Finally, a participant stated,

> I like to use situations that the students can relate to. If the students can relate, they will be more engaged in the learning process and willing to learn. For example, change word problems to have your students' names and create problems dealing with cell phones, sports, and music.

The participant statements suggested that employing pedagogical practices that infuse cultural diversity is another critical aspect of CRP. Participants overwhelmingly discussed the importance of employing pedagogical practices that infuse cultural diversity as a definition of CRP. The next part of the professional development session focused on the participants engaging in T*t*PS using RMTs; the second construct of the CREPS pedagogy framework (see Figure 5).

Figure 5.

A Framework for Developing the CREPS Pedagogy *Highlighting TtPS*



Navigating an Understanding of the CREPS pedagogy

Teachers navigated their understanding of the CREPS pedagogy before and after completing a Rich Mathematical Task (RMT). Upon analysis of teachers' perceptions, patterns across the data revealed that some of teachers' early perceptions before they completed the RMT were solidified, while some of their perceptions changed after going through the process themselves. Thus, the data was organized to fit the sub-themes of a) teachers' original perceptions of RMTs and b) changes to teacher's perceptions of RMTs. Each of the sub-themes will be discussed below.

Teachers' Original Perceptions of RMTs

Before completing a mathematical task, teachers identified a RMT to have characteristics that require the use of the higher levels of Bloom's Taxonomy. For example, one participant noted, *"Here in these problems [referring to high cognitive demand tasks], it's more analyzing, interpreting and creating, but in the other problems [referring to low cognitive demand tasks] it's basically more identifying and remembering."* Similarly, another participant indicated, *"So, I'm saying it's high because they have to compare the situations in the problem, and the question asks them to make a prediction. Will you have enough money on the 10th day?"* After completing a task, teachers confirmed that rich mathematical tasks should be high level cognitive demand tasks that involve understanding, analyzing information and applying it, and evaluating strategies as indicated by the high levels of Bloom's Taxonomy.

Teachers also noted that allowing for multiple entry and exit points to students with a wide range of skills and abilities is a characteristic of rich mathematical tasks. Prior to and after completing a task, the teachers agreed that the task should be able to be approached in a variety of ways and have varying degrees of challenge within it to accommodate the diversity of

learners. For example, a participant explained, *"if a student does not know how to do it this way but I know how to do it that way then they can still solve the problem using the strategy that they know better."* Students should engage in a task in a way that makes sense to them, rather than replicate a procedure shown to them. Another participant said,

> I think this will be good to give them at the beginning just to see what they already understand. Especially like an Algebra 1 student. It could be a pre-assessment before that unit starts. You could see what they remember and what they don't remember. And that could guide how you're gonna teach it.

Teachers recognize that the same task can be used across grade levels and have different purposes.

Lastly, teachers identified requiring justification and explanation as another characteristic of a rich mathematical task. Teachers agreed that students should have to justify or explain their reasoning. For example, one participant said,

> …sometimes kids get a correct answer for the wrong reason, using the wrong approach. So, when we're asking them to justify, we're asking them to share their thought process. How did you go about this? So, it's not just is it right or wrong? But what were you thinking that led you to this answer?

Teachers believe that math tasks that encourage students to justify their thinking and explain how they got their answers are important because it helps them analyze their approach to a problem and the process(es) they used to find a solution.

Changes to Teachers' Perceptions

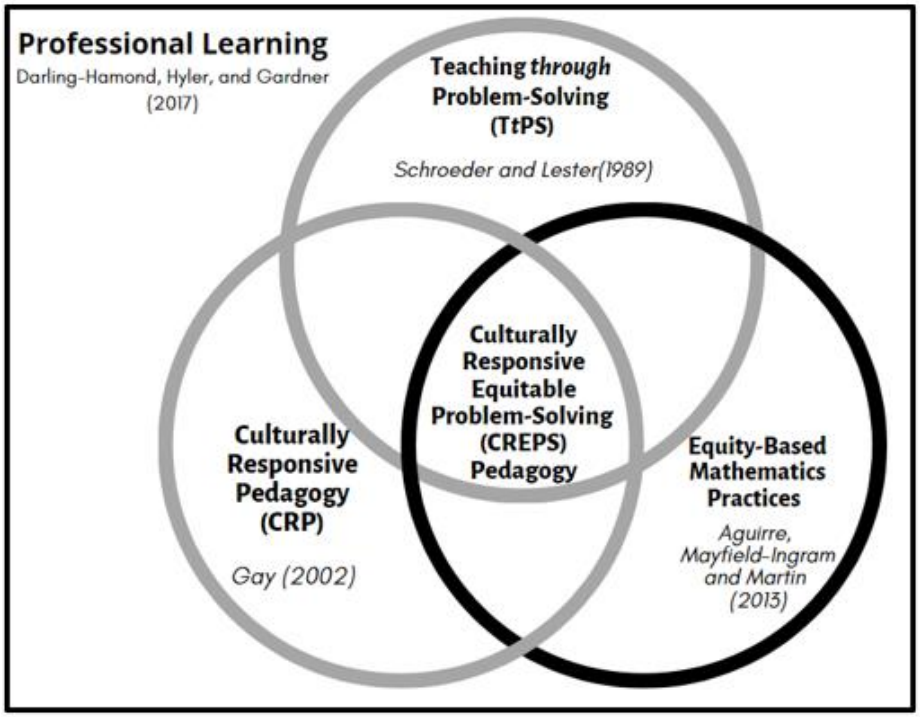
Although teachers' descriptions and actions often mirrored one another, there were times when their actions provided key components that were left out of their descriptions of RMT and

TtPS. When teachers originally characterized rich mathematical tasks, teachers omitted allowing for multiple solution pathways and the use of varied representations. While completing a task one teacher noted *"I used a table to find my answer and the other option I used an equation."* Another teacher added by saying, *"And some students may want to draw a picture or a graph."* Teachers discovered through engaging with the RMT, that allowing for multiple solution pathways and the use of varied representations should be included as key characteristics of a rich mathematical task.

Another characteristic that teachers omitted in their descriptions but used after completion of the task was that the context of the task should be relevant. For example, a teacher explained, *"This problem talks about jobs like babysitting, cutting grass, and doing chores. These jobs are relevant to the age of our students because they aren't old enough to get real jobs."* Similarly, another participant said that *"the kids in the task were doing those jobs to save money to go to an amusement park and that is definitely relevant. All our students like to ride roller coasters."* The other teachers agreed that this is important because it encourages connections among ideas. The last part of the professional development session focused on how equity-based practices look in a mathematics classroom; the third and final construct of the CREPS pedagogy framework (see Figure 6).

Figure 6.

A Framework for Developing the CREPS Pedagogy *Highlighting EBMP*



Connecting with Components of the CREPS pedagogy

During the professional development session, teachers began to make connections with the components of the CREPS pedagogy through the discussions of equity-based mathematics practices. The analysis of patterns from the data revealed the teachers' perceptions of equity-based mathematics practices were warranted through previous experiences in the professional development session and through examples of their lived experiences. Thus, the data was organized to fit the sub-themes that included: a) deepening the mathematics content; b) creating safe spaces; and c) embedding collaborative learning opportunities. Each of the sub-themes will be discussed below.

Deepening the Mathematics Content

Professional development participants recognized the importance of developing a deep understanding of mathematical content. The CREPS pedagogy is a pedagogical approach to teaching mathematics that acknowledges the need for teachers to help students develop a deep understanding of mathematics. During our discussions about the characteristics of equity-based mathematics classrooms, we emphasized the importance of supporting students in analyzing, comparing, justifying, and proving their solutions. One participant muttered, *"We just did that."* The other participants nodded in agreement. The discussions also included the importance of teachers presenting tasks that have high cognitive demand and include multiple solution strategies and representations. Other participants made comments like, *"We just experienced that when we completed the task," "We just heard that before,"* and *"We just did that."* Lastly, we talked about how equity-based mathematics practices included presenting tasks that offered multiple entry points, allowing students with varying skills, knowledge, and levels of confidence to engage with the problem and make valuable contributions. A participant interjected, *"So, it sounds like if we do tasks like we just completed, then we're being equitable."* These comments provided evidence that participants related to the components of the CREPS pedagogy framework.

Creating Safe Spaces

Professional development participants recognized the importance of creating safe spaces for students in their mathematics classrooms. The CREPS pedagogy is a pedagogical approach to teaching mathematics that acknowledges the need for teachers to help students understand that it is acceptable to make mistakes. In discussing the characteristics of equity-based mathematics classrooms, the participants recognized that, as teachers, we need to make students aware that mistakes and incorrect answers are sources of learning and not punishments. One participant

said, *"I let my students know that if you make a mistake in your answer, that you will not be ridiculed or made fun of."* Another participant commented that she tells her students, *"Don't be afraid to make a mistake."* In addition, a participant's example included,

> *What I do with my students, as far as mistakes go, I try to make it a positive thing instead of negative. I tell them not to say they made a mistake. I tell them to say that their brain is growing*.

One participant added, *"I tell my students, if you get it wrong, I'm not gonna feed you to the alligators. We are going to work on it until we understand it."* These comments provided more evidence that participants were relating to the components of the CREPS pedagogy framework.

Embedding Collaborative Learning Opportunities

Professional development participants recognized the importance of embedding collaborative learning opportunities in their mathematics classrooms. The CREPS pedagogy emphasizes pedagogy that builds student competence, reduces the status quo, and values multiple mathematical contributions. Traditionally, mathematics learning has focused on teaching practices that include lectures and seatwork. Students who struggle in this traditional classroom environment are often marginalized, ignored, or labeled as "dumb" (Aguirre et al., 2013). In discussing the characteristics of equity-based mathematics classrooms, the participants recognized that, as teachers, we need to challenge these spaces of marginality by embedding collaborative learning opportunities in mathematics instruction. In their reflective journals collectively, some teachers' comments about why collaboration is important included, *"Students are able to share their thinking,"* and *"Students can learn from each other."* When teachers provide opportunities for students to share their reasoning aimed at making sense of and using mathematical ideas, they are positioning them as being mathematically competent. Other

participants included, *"Students can get multiple perspectives and realize that sometimes there is more than one way to approach a problem," "It can help students make connections among different approaches,"* and *"If it is used before students complete a problem, it could spark dialogue on how to solve it."* Collaboration in a mathematics classroom supports making math accessible for all students. These reflections provided evidence that participants were recognizing the connections between the components of the CREPS pedagogy framework. One might conclude that since participants had similar experiences as the characteristics suggest that they can relate to equity-based mathematics classroom practices. Therefore, participants have a better understanding of the CREPS pedagogy framework.

Discussion of Findings

This section begins with an overview of the purpose of this study, the research questions, and a discussion of the findings. The discussion will include how the qualitative results explain the quantitative results and the relationship to literature related to the CREPS pedagogy. The section concludes with a discussion of the limitations of the study and implications for future research and practice.

Research Overview

The purpose of this research is to explore ideas of how to improve Black students' opportunities to engage in effective mathematical problem solving to improve their mathematics understanding and achievement. This essay aimed to understand whether teachers believed they were ready to teach in a culturally responsive way and to capture teachers' perceptions as they participated in professional development designed to introduce culturally responsive equitable problem-solving pedagogy (the CREPS pedagogy). This study was guided by the research questions below:

RQ1: At what levels do secondary mathematics teachers from a large predominantly Black school district rate their readiness for teaching as measured by the Culturally Responsive Teaching Readiness Scale?

RQ2: How do secondary mathematics teachers from a large predominantly Black school district perceive culturally responsive teaching?

RQ3: How do you prepare secondary mathematics teachers to understand Culturally Responsive Equitable Problem Solving (CREPS) Pedagogy?

Discussion of Findings

The participants' CRP readiness total mean scores on the CRTRS were relatively high, which shows that in-service secondary mathematics teachers who participated in the survey perceived themselves as ready to teach in a culturally responsive way. In prior studies, researchers concluded that teachers, whether preservice or in-service, perceived that they had a high level of CRP readiness because of their high mean scores on the CRTRS scores (Moore et al., 2021; Özüdoğru, 2018; Zorba; 2020). Similarly, in this study the participants' CRTRS scores were high. Although the in-service teachers' CRP readiness total mean scores ($M = 4.06$) were lower than the mean scores reported by Moore et al. (2021) ($M = 4.25$), their scores were higher than both mean scores reported by Zorba (2020) ($M = 3.64$) and Özüdoğru's (2018) ($M = 3.63$), who categorized their participants' readiness for CRP as high. Therefore, I assert that the participants in this study perceived themselves as ready for CRP. However, this finding only quantifies the participants' perceptions of their readiness for CRP but does not explain the nature of the readiness. Hence, I turned to the findings of the qualitative analysis for greater insights into the nature of the participants' CRP understanding.

While participants perceived themselves as ready for CRP, the results of the professional development indicated that teachers had some gaps in their understanding of CRP. In their study to determine teachers' understanding of CRP, Ebersole et al. (2016) placed teachers in three categories: teachers that understood CRP as "doing culturally responsive activities," "moving toward culturally responsive perspectives," and "being a culturally responsive teacher" (p. 101). In each of the cases, teachers perceived themselves as teaching in a culturally responsive way. Examining the participants' reflective journals, teachers described several characteristics of Gay's (2002) CRP practices. For example, these comments included: (a) developing cultural diversity knowledge; (b) demonstrating cultural caring and building a learning community; and (c) using cultural congruence in classroom instruction. However, implementing cross-cultural communications and designing culturally relevant curricula were both omitted in the teachers' journals. One might conclude that they were not as familiar with CRP as they perceived due to the omission of comments. The teachers' perceptions about their CRP readiness likely exceeded their readiness to enact CRP.

While the participants' understanding of CRP did not directly align with every CRP practice, their understanding emerged through engagement of the composite parts of the CREPS pedagogy framework. In several studies, participants had a greater understanding of CRP after engaging in CRP-related activities (Bonner et al., 2018; Ebersole et al., 2016; Frye et al., 2010; Karatas & Oral, 2015; McKoy et al., 2017; Mette et al., 2016; Samuels, 2018). As participants engaged in each component of the CREPS pedagogy framework, they noticed the synergy between CRP and RMTs, which led to understanding key aspects of T*t*PS. For example, Cai (2003, 2015) argued that when T*t*PS, one of the roles of teachers is to select or develop worthwhile or genuine problems. For this study, we refer to these types of tasks as rich

mathematical tasks (RMT). To select these types of tasks, teachers need to understand the characteristics of RMTs (Boaler, 2016; Cai, 2003; King, 2019; Lester 2013; Lester & Cai, 2015; Van de Walle, 2018). Before engaging in the T*t*PS, teachers identified several characteristics of RMT. However, they added additional characteristics after completing the RMT that included aspects of CRP. As participants continued to engage in the components of the CREPS pedagogy framework, they observed the overlapping features of CRP, T*t*PS, and equity-based mathematics classroom practices. For example, teachers related to one aspect of Aguirre et al.'s (2013) equity-based practices in mathematics classrooms, *going deep with mathematics*, when they completed the RMT from this professional development. Equitable teaching requires teachers to provide rich learning experiences for all students, not only allowing them to master specific content, but also allowing them to experience a sense of agency in doing and learning mathematics (Aguirre et al., 2013; Webel & Dwiggins, 2019). Consequently, one might conclude that engaging teachers in the components of the CREPS pedagogy supports their emergent understanding of the synergistic relationship of those components as a comprehensive framework for problem-solving.

Limitations

This study has several major limitations. This study was a mixed methods study that utilized the CRTRS instrument. A limitation that is specific to the CRTRS instrument is that it is not field-specific. There are several limitations of conducting survey research. When surveys are conducted, the researcher relies on self-reported data. Self-reported data may be exaggerated or contain biases that may affect the results. There is a risk of participants not providing accurate and honest answers. A level of social desirability bias may commence because some participants want to help the researchers develop desired conclusions. At the time this survey was conducted,

the school district had been overloaded with several surveys and questionnaires requesting information about the school's climate. Because of this, the participants may have acquired survey fatigue. The survey was taken anonymously; therefore, the researcher did not know how the 10 professional development participants rated themselves. Another limitation of this study was the amount of time participants had to engage in professional development. The professional development session was not ongoing. To improve teaching practice, teachers should spend more time engaged in professional development to include contact hours and duration. Due to time constraints, ongoing professional development sessions were not able to be completed. Because of the one-time professional development session, the learning from the professional development could not be linked to praxis. Lastly, due to the small number of participants that participated in the survey (n = 51) and the professional development (n = 10), the results of the study cannot be generalized. The data gathered from the professional development may not reflect the perceptions of other in-service secondary mathematics teachers.

Implications for Practice

The results of this study have implications for practice. Due to the diverse demographics of school districts, it is as important to sustain that learning in in-service teacher training. The participants in this study were provided professional development on the CREPS pedagogy framework; therefore, their understanding of the CREPS pedagogy was emergent. Effective professional development is job-embedded and continues over a sustained period (Darling-Hammond et al., 2017). Teachers should be provided with ongoing professional development to gain a deeper understanding of how to implement the CREPS pedagogy in their mathematics instruction. As teachers' level of understanding of the CREPS pedagogy develops, professional development should be customized to meet their needs.

When teachers participate in ongoing professional development on the CREPS pedagogy, they could serve as support for others who are trying to implement it in their instruction. For teachers to be able to effectively implement the CREPS pedagogy, they must be provided with opportunities to learn about, implement and reflect upon the pedagogy. Although teachers are provided with planning periods during the school day, this time is minimal. Currently, teachers are not afforded ample opportunities or time to collaborate with other teachers to plan for mathematics instruction. Once teachers are provided professional development on the CREPS pedagogy framework, more time will be needed to plan for implementation. Therefore, another implication is to provide teachers with the ample opportunity and time to work together to develop lessons that infuse the CREPS pedagogy framework.

Recommendations for Future Research

The results of this study have important implications for future research. To support teachers' adoption of CREPS pedagogy for mathematics teaching will require affording them opportunities to engage in professional learning involving collaborative and practice-centered experiences (Akiba et al, 2019; Dudley et al., 2019; Murata et al., 2012; Takahashi et al., 2013). A recommendation for developing teachers' CREPS pedagogical knowledge is to afford them opportunities to participate in engaging in CREPS pedagogy as learners to introduce the CREPS pedagogy.

Conclusions

The teaching profession requires today's teachers to engage all students, and in the United States more and more schools are becoming culturally diverse. Thus, this essay aimed to understand whether teachers believed they were ready to teach in a culturally responsive way and to capture teachers' perceptions as they participated in professional development designed to

introduce the CREPS pedagogy. This study determined that engaging teachers in the components of the CREPS pedagogy supports their emergent understanding of how these components work together as a comprehensive framework for problem-solving. Therefore, I contend that teachers should be provided with ongoing professional development to gain a deeper understanding of how to implement the CREPS pedagogy in their mathematics instruction.

CHAPTER 4

ESSAY 3 – CONCEPTUALIZING CULTURALLY RESPONSIVE EQUITABLE PROBLEM-SOLVING PEDAGOGY

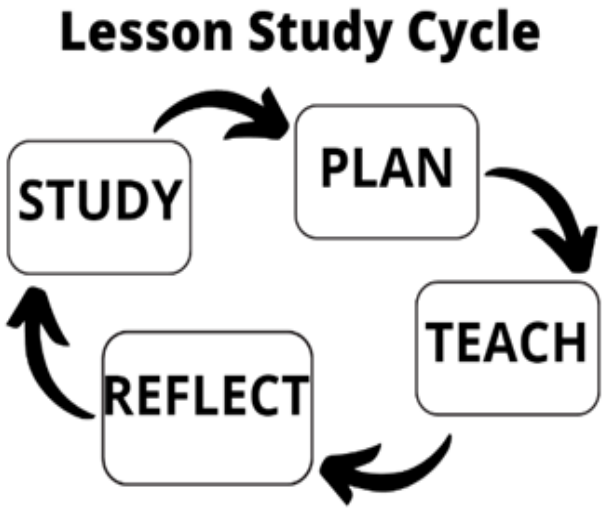
Historically, Black students in K-12 classrooms have been underserved which has contributed to diminished achievement when compared to that of their white peers in the mathematics classroom. In response to these mathematics inequities, examining the pedagogical practices of educators has been identified as a way to narrow the gap. Traditionally, in many classrooms one might conclude that the most used approach to instruction in mathematics classes at all levels continues to be direct instruction. According to researchers in the late 20th century, for example Peterson (1988), "students learn more efficiently when their teachers first structure new instruction for them and help them relate it to what they already know, then monitor their performance and provide corrective feedback recitation, drill, practice, or application activity" (p. 5). However, in more contemporary publications, the National Council of Teachers of Mathematics (NCTM) and other released documents advocating for mathematics instruction that actively engages students use of mathematical practices to develop and deepen their mathematics thinking and understanding of concepts, procedures, and ideas (CCSSI, 2010; NCTM, 2014). Despite this call for change, many mathematics teachers continue to use "repetition; drill; convergent right-answer thinking; and predictability" (Ladson-Billings, 1997, p. 699), which does not address the needs of Black students. While deep understanding, problem solving, critical thinking, and communication are necessary, many math teachers may lack the skill set to implement this type of teaching. The purpose of this research is to explore ideas of how to improve Black students' opportunities to engage in effective mathematical problem solving to improve their mathematics understanding and achievement. The following research question will

guide this case study: How do in-service secondary mathematics teachers, with an emergent understanding of the CREPS pedagogy, enact its features through collaborative planning and iterative teaching?

Lesson study, a collaborative, practice-based cycle of inquiry that centers around study, planning, observation, and analysis of actual classroom lessons (Takahashi et. al., 2013), possesses the characteristics of effective professional development. Lesson study embeds teachers' learning in their everyday work which increases the likelihood that their learning will be meaningful (Fernandez et al., 2003). It involves a group of qualified teachers, generally within a single school, working together as part of a lesson study group to examine and better understand effective teaching practices. Figure 7 depicts the steps involved in the cycle of a lesson study.

Figure 7.

The Lesson Study Cycle



Note: Adapted from *What is Lesson Study?* The Lesson Study Group at Mills College. (2021, November 16).

Within the four phases of the lesson study cycle, the group of teachers works collaboratively to study and plan a lesson that addresses a pre-established goal before implementing and reflecting on the impact the lesson activities had on students' learning. Takahashi and colleagues (2013) describe the steps for practicing lesson study as study, plan, teach, and reflect. The first step of the lesson study cycle is called the study phase. A team of teachers considers their long-term goals for students and chooses a specific area of instruction they want to improve. Equipped with curiosity, they look beyond their own classrooms to study what other teachers and researchers know about this area of instruction and bring it back to their own curriculum. The second step of the lesson study cycle uses insights from the study phase. The team focuses in depth on one unit of their curriculum, co-planning one lesson within the unit. The unit and lesson plan bring to life teachers' vision of high-quality teaching-learning, their insights from the study phase, and their knowledge about their own students' thinking. The next step in the lesson study cycle requires the team of teachers to put the lesson into action. One teacher brings to life the team's lesson in the classroom, while other team members carefully observe individual students, taking notes and photos that help them understand the lesson from students' viewpoints. This can be a thrilling moment for every team member, seeing how their ideas play out in the real world of the classroom. Reflect is the last step in the lesson study cycle. Soon after the lesson is taught, teachers meet for a post-lesson discussion. They share data from individual students, building a picture of student learning. As teachers share their observations, they deepen their curiosity about student thinking and reconnect with their passion for learning. Using shared data, the lesson can be revised, polished, and retaught. As a result, the insight gained by studying one lesson can be generalized to influence teachers' strategies for all lessons (Stigler & Hiebert, 1999; Takahashi et. al., 2013). Although the lesson study approach was

utilized in this study, it was not the focus. It served as a vehicle for gathering data about the execution of the CREPS pedagogy framework.

In the sections that follow, I present an introduction to the CREPS pedagogy to include a description of the pedagogical goals and characteristics of lessons needed to implement CREPS during mathematics instruction. Then, I provide the details of the research method including research design, context, and participants, as well as data collection procedures, analysis, and the role of the researcher. Finally, a thematic presentation of results is reported followed by a discussion of findings with connections to the literature, limitations, and implications that includes suggestions for additional research.

Culturally Responsive Equitable Problem-Solving Pedagogy Conceptual Framework

The CREPS pedagogy, (see The CREPS pedagogy (see Figure 2) is an asset-based framework used to examine problem-solving teaching practices of mathematics teachers of Black students. The CREPS pedagogy is a synthesis of three pedagogical ideas: Gay's (2002, 2010, 2018) Culturally Responsive Pedagogy (CRP), Aguirre, Mayfield-Ingram, Martin's (2013) Equity-Based Mathematics Practices, and Schroeder and Lester's (1989) Teaching *through* Problem-Solving (T*t*PS). When these pedagogies are merged and situated within professional learning, they make a powerful combination for teaching mathematical problem-solving to all students, including Black students.

Figure 2) is an asset-based approach to examine problem-solving teaching practices of mathematics teaching designed especially for Black children. However, it is worth noting that the CREPS pedagogy is presumed effective for ALL mathematics learners, adults and children. CREPS is a pedagogy informed by: Gay's (2002) Culturally Responsive Pedagogy (CRP), Aguirre, Mayfield-Ingram, Martin's (2013) Equity-Based Mathematics Practices, and Schroeder and Lester's (1989) Teaching *through* Problem-Solving (T*t*PS). At the root of the CREPS pedagogy is the belief that Black children can be successful mathematical problem solvers when teachers use pedagogy that affords opportunities for their learning. More specifically, for teaching using the CREPS pedagogy, there are three pedagogical goals that establish the learning environment: (a) development of deep mathematics understanding; (b) acknowledgement of students' backgrounds; and (c) employment of equitable pedagogical practices. Establishing the environment requires mathematics teachers to make specific pedagogical goals using lessons with specific characteristics (see **Error! Reference source not found.**).

Methods

This section introduces the methodology used for this research study. This study sought to answer the following research question: How do in-service secondary mathematics teachers, with an emergent understanding of the CREPS pedagogy, enact its features through collaborative planning and iterative teaching? This section will begin with an overview of the research design, research context, and a description of the study participants. This is followed by a description of the sources of data collection and the procedures used to collect the data. Finally, there will be a detailed account of how the data was analyzed.

Research Design

The research design for this study employed a qualitative exploratory case study design. The goal of this study is to gain insights into how secondary mathematics teachers make meaning and build knowledge (Merriam & Tisdell, 2016) about the CREPS pedagogy through professional learning that uses iterative teaching. Merriam and Tisdell noted that the researcher doing qualitative research should have a tolerance for ambiguity, be sensitive to context and data, and be a good communicator. Merriam and Tisdell (1998) defined qualitative case study as "an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process, or a social unit" (p. xiii). The case study approach was most appropriate, as it allowed for an in-depth description and analysis of the instances of teaching with respect to the teachers' perceptions when mathematics teachers were tasked with teaching a lesson using the CREPS pedagogy. Martinson and O'Brien (2015) described the exploratory case study as being aimed at defining the questions and hypotheses of a subsequent study. Due to the in-depth research and analysis, the exploratory case study design is most appropriate for this study.

Research Context

Describing the context in which this study was conducted is crucial because it gives the reader a better understanding of the background of the research (Creswell & Poth, 2018). This study was conducted in a large urban school district located in a southeastern state. The school district has approximately 27,300 students enrolled with 60.9% identified as receiving free or reduced lunch, 14% identified as learning disabled, and 5% are English Language Learners. The student enrollment demographics are found in Table 17.

Table 17.

Student Demographics

Ethnicity	*n*	%
American Indian	92	0.3%
AAPI	574	2.1%
Black	15,576	57.0%
Hispanic	3,654	13.4%
Two or more	1,865	6.8%
White	5,569	20.4%

Note: This data reflects the 2022-2023 school year.

Regarding mathematics student achievement, approximately 46% of the students were proficient on the end of the year state assessments in 2022. Thirty-five percent of Black students were proficient compared to 69% of white students.

Researcher Positionality

Researcher positionality is the position that a researcher has chosen to adopt within a research study. There are many facets that make up the researcher's positionality, most of which embody markers of minority groups. In this research study, the sole researcher is a 50-year-old Black woman, working toward a doctorate in curriculum and instruction in mathematics education. As a Black woman, I understand that we do not experience racism and sexism as separate discrete strands of oppression, rather as a combination or intersectionality. Intersectionality is the term coined by Crenshaw (2017) to describe the unique experiences of discrimination that Black women face. As the sole researcher, I am aware of my positionality and role within this study and understand how my perceptions would affect the study.

The driving force behind my research grew from my previous and current experiences as a mathematics teacher and a mathematics supervisor in urban school districts. To effectively engage ALL students in mathematics problem solving, educators must be aware of and prepared for the diversity of today's classrooms. As a Black student, I was an average performing math student. I understood math when just numbers and operations were involved but struggled when confronted with mathematical problem-solving. Because I had trouble understanding problem-solving as a student, as a former secondary math teacher, I had difficulty planning and teaching mathematical problem-solving effectively. Currently, I serve as a mathematics supervisor in the school district where this study was conducted so, I am passionate about helping other teachers teach Black students to be mathematical problem solvers. These struggles, as a math student,

math teacher, and math supervisor have led me to question whether others have the same difficulties and whether this is a systemic issue.

Participants

An important step in the research process is to find and gain access to people to study so that good data can be collected (Creswell & Poth, 2018). I used a purposeful sampling strategy, which is intentionally sampling a group of people that will inform the researcher about the problem being examined. According to Creswell and Poth (2018), purposive sampling requires the development of specific criteria for the inclusion of participants. The specific criteria included teachers who: (1) are currently teaching secondary mathematics, (2) have three or more years of secondary mathematics teaching experience and (3) are currently teaching in the school district of interest. The participants in this case study were unique in that they were part of a group of teachers involved in professional development regarding the CREPS pedagogy. Participants were recruited via email solicitation after attending a professional development session on the CREPS pedagogy. This case study was bound to a group of three participants, all of them were high school mathematics teachers. In examining similar studies involving the lesson study approach (e.g., Barber, 2021; Suh et al., 2020; Warwick et al., 2016; Won, 2017), the number of participants per lesson study team ranged from three to ten to provide in-depth details about the participants' perceptions and experiences. Thus, three participants were adequate for my study.

According to Hays and Singh (2012), researchers must deal with ethical issues, a set of guidelines established within a professional discipline to guide thinking and behavior, when their intended research involves human beings. The main ethical issues that will be considered in conducting this research study are autonomy and confidentiality. Autonomy refers to the right of

individuals to choose. In this research study, participants were given a letter of informed consent (see Appendix I) that was approved by ODU's Institutional Review Board that clearly stated the risks and benefits of participation in this research. The informed consent letter provided the participants with details of the nature and purpose of the research, who will have access to the data, and who to contact if they had an issue with the research or researcher. Each participant read and signed the informed consent form prior to the start of the study. The American Psychological Association (2020) necessitated that researchers maintain participants' privacy and confidentiality in the research process and in the data the participants offer. Reasonable steps were taken to keep participants' private information, such as name, age, or school affiliation, confidential. Pseudonyms were used when referencing data connected to the participants to reduce the risk of anonymity being compromised. The participant demographics and a description of their initial perceptions of the CREPS pedagogy follow (see Table 18).

Table 18.

Participant Overview

Pseudonym	Sex	Age	Ethnicity	Years of Experience	Teaching Context	Degree; Teaching Certifications	Subjects taught
Paula	F	59	Black	17	HS	BA; secondary mathematics	Alg1, Geo, Prob & Stat, AP Stat
Tiffany	F	51	Black	15	HS	MA; secondary mathematics	Math Analysis, AFDA
Sabrina	F	60	Black	30	HS	BA; MS mathematics, Algebra 1, & computer science	Algebra 1

Paula is a 59-year-old Black female that has been teaching for 17 years. She has a bachelor's degree and is endorsed to teach middle and high school mathematics. She currently

teaches high school Algebra 1, Geometry, Probability and Statistics, and Advanced Placement Statistics. Paula initially defined the CREPS pedagogy as “using mathematical tasks, that relates to a real application of mathematics students can make a connection with and that allows students to have different ways or methods to find the solution to the tasks.” She believes that during mathematics teaching teachers should be, “circulating around the room assessing student learning and asking questions to build on that learning.” She also believes that during mathematics learning students should be, “working on tasks individually first to develop an understanding and then discussing solution strategies with their group members.”

Tiffany is a 51-year-old Black female that has been teaching for 15 years. She has a master’s degree and is endorsed to teach middle and high school mathematics. She currently teaches high school Math Analysis and Advanced Functions and Data Analysis (AFDA). Tiffany initially defined the CREPS pedagogy as “providing all students the opportunity to experience rich and engaging tasks via mathematical problem solving.” She believes that during mathematics teaching teachers should, “serve as facilitators and affirm strategies that promote mathematical discourse.” She also believes that during mathematics learning students should be, “communicating with each other, drawing pictures or diagrams, and listening to others’ opinions or strategies to solve the task.”

Sabrina is a 60-year-old Black female that has been teaching for 30 years. She has a bachelor’s degree and is endorsed to teach middle school mathematics, Algebra 1, and computer science. She currently teaches high school Algebra 1. Sabrina initially defined the CREPS pedagogy as “teaching math using situations that students can relate to.” She believes that during mathematics teaching teachers should, “use situations where the student may have prior knowledge about the problem. The situations will engage them to put forth an enjoyable effort

and do a better job solving practical problems." She also believes that during mathematics learning students should be, "using related experiences to help them develop strategies to use to solve problems."

Lesson Study Procedures

In the lesson study, participants spent about 20 hours working individually and collaboratively to complete a full lesson study cycle. Participants worked in iterative cycles that consisted of four phases: 1) study and plan, 2) teach and observe, 3) debrief and revise, and 4) debrief, reflect, and report. Phases 2 and 3 repeat with each iteration of the research lesson teaching. In this investigation, the lesson study consisted of synchronous Zoom and asynchronous sessions, which were articulated in Table 19.

Table 19.

Lesson Study Activities and Timeline

Meeting #	Lesson Study Activities	Phases
1	● Developed Group Norms ● GoReact Software Demonstration ● Determined Specific Lesson Focus ● Reflection Journal Introduction	Phase 1 - Study and Plan (Synchronous)
2	● Content/Teaching Practice Professional Development ● Plan Research Lesson (iteration #1)	Phase 1 - Study and Plan (Synchronous)
3	● Teach Lesson (iteration #1) ● Observe Lesson using GoReact (iteration #1) ● Reflection Journal #1	Phase 2 - Teach and Observe (Asynchronous)
4	● Collaboratively Debrief ● Revise Lesson (iteration #2)	Phase 3 - Debrief and Revise (Synchronous)
5	● Teach Lesson (iteration #2) ● Observe Lesson using GoReact (iteration #2) ● Reflection Journal #2	Phase 2 - Teach and Observe (Asynchronous)
6	● Collaboratively Debrief ● Revise Lesson (iteration #3)	Phase 3 - Debrief and Revise (Synchronous)

7	● Teach Lesson (iteration #3) ● Observe Lesson using GoReact (iteration #3) ● Reflection Journal #3	Phase 2 - Teach and Observe (Asynchronous)
8	● Collaboratively Debrief ● Reflection Discussion ● Reflection Journal Conclusion	Phase 3 - Debrief Phase 4 - Reflect and Report (Synchronous)

Meeting #1

At the beginning of the lesson study, the researcher and participants met synchronously using the Zoom platform to develop group norms for the lesson study, learn how to use the GoReact software, determine the specific lesson focus, and complete the initial reflection using a set of introductory questions (see Appendix K). The participants agreed on five norms: be punctual, stay on task, listen with an open mind, be positive, and be respectful. In addition to the norms, the group emphasized that the focus was on the lesson and student learning, and not about evaluating the teacher. After the norms were established, the participants attended a brief session on how to use the GoReact software program. Using a sample video that was uploaded to the software platform, the participants practiced observing a video, inserting observational notes and making annotations within the video with timestamps. Next, they agreed on a specific lesson focus. They chose to use a task that they experienced during the CREPS pedagogy professional development, one in which their students had not experienced. The original task, *Summer Passes,* was intended to be taught to middle school students (see Appendix H).

The *Summer Passes* task described three students who were planning to purchase summer passes at a local amusement park and decided to work jobs to earn the money. There were three scenarios that described how each student was going to earn their money. One scenario was a

proportional relationship where the student would earn $10 each day. Another scenario was an additive relationship where the student would get $50 upfront and earn $1 a day. The last scenario was an additive relationship where the student had already saved $35 and earned $1 a day. The task asked, “who would be the first one to have enough money to buy the pass if the pass cost $86?” and “how long before they can all go together?” In addition, the task required an explanation and justification. The task was a high cognitive demand task that had to be revised to meet the components of the CREPS pedagogy. After the synchronous Zoom session, participants completed the reflection journal introduction questions.

Meeting #2

During the next meeting, a synchronous Zoom session, the participants attended a mini-PD session designed by the researcher that reviewed the components of the CREPS pedagogy. Using the learnings from the professional development, the participants collaboratively planned the first iteration of the research lesson (see Figure 8, also Appendix J).

Figure 8.

Rich Mathematical Task - Summer Passes

Summer Passes

Dontae, Amber, and Roberto plan to purchase summer passes to Busch Gardens. They decide to work after-school jobs to earn the money for the summer passes.

Dontae will babysit his little brother every day. He will earn $10 a day for babysitting.

Amber's sister has a summer lawn care business. Amber will help her sister pull weeds out of the flower beds every day. Her sister will pay her $50 upfront and then a dollar each day.

Roberto has already saved $35 for his summer pass. His mom agrees to give him one dollar for every day that he does his chores. Roberto does his chores every day.

If a summer pass to Busch Gardens costs $86, who will be the first one to have enough money to buy the pass? How long will it be before they can all go together? Explain your reasoning and give evidence of your position.

Note: Adapted from VDOE 2019

They discussed changes to the original task itself and then how the task would be implemented. Following that, they developed the lesson plan to include a launch, implementation, discussion, and closure. They established a learning goal for the lesson, "Students will be able to represent a

scenario using several representations". They also created a formative assessment in the form of an exit ticket that would reflect the student learning of the intended goal (see Figure 9).

Figure 9.

Research Lesson Exit Ticket

Summer Passes - Exit Ticket

Asia wants to go on the trip to Busch Gardens also. She is going to tutor after school to earn money for summer passes, but she owes her brother $24. She will make $5 per day.

Represent this situation using a table, graph, and equation.

If a summer pass to Busch Gardens costs $86, how long will it take her to have enough money to buy the pass.

In addition, they discussed ways to implement the CREPS pedagogy within their delivery of the lesson. They included guiding questions that they would use to advance and assess student learning while the students completed the task.

Meetings #3 - 8 (Three Iterations of Phases 2 and 3)

Once the initial research lesson plan was complete, the first participant taught the lesson, and the researcher videotaped. This was the beginning of phase 2 of the lesson study process, meeting #3. The researcher prepared and uploaded the first research lesson teaching video to the GoReact program. The participants observed the teaching video, made comments and annotations on the video using the GoReact software, as well as completed a reflection journal entry (see Appendix K) for the research lesson teaching. The reflection journal asked participants

to identify strengths and opportunities for the next research lesson teaching. Meeting #4 followed a post research lesson teaching protocol, which consisted of three segments: (a) the participant who taught the research lesson offered a reflection about the instruction; (b) the other participants shared salient comments about the observed research lesson teaching, and (c) participants collaboratively discussed ideas for revising the research lesson. These two phases, 2 and 3, were repeated following the processes described for two more iterations of teaching the research lesson.

In the final phase 3 and 4, meeting that followed the third iteration of teaching, meeting 8, the participants discussed and summarized the results of the lesson study. The researcher posed several questions to guide the discussion (see Appendix K), focusing on examining participants' changes in perceptions regarding their professional learning related to the lesson study and the CREPS pedagogy. This meeting concluded with the participants' completing a final reflection journal entry (see Appendix K).

Data Sources

Data will be triangulated using several types of data sources. Creswell and Poth (2018) stated that case study data collection involves multiple forms of data collection as the researcher builds an in-depth picture of the case. To develop the case, data sources included video recordings and transcriptions of the lesson study meetings and classroom teachings of the research lesson. Other data sources included participants' annotations on the video recorded teachings, iterations of the evolving research lesson plan, participant teachers' written reflections, and lesson artifacts. A description of the data sources follows.

Observations. Observations play an important role in examining teachers' understanding and knowledge about the CREPS pedagogy. Merriam and Tisdell (2016) stated that

"observational data represent a firsthand encounter with the phenomenon of interest rather than a secondhand account of the world obtained in an interview" (p. 94). The participants collaborated to develop the initial lesson plan, and then they revised the lesson plan after each iteration of teaching. Because the teachers worked in different school buildings, I observed each time the research lesson was taught, videotaped the teaching. The recordings were uploaded into a software program called GoReact, which allowed the participant teachers to observe the teaching, mark specific instances of the teaching, and leave annotations about the teaching. Participants used GoReact to observe and comment about the research lesson each time it was taught. Between each teaching, we met online synchronously to collaboratively debrief and revise the lesson, and asynchronously participants were expected to either teach or observe the teaching on the GoReact platform. These lesson study meetings occurred using the Zoom platform, and they were recorded and transcribed as part of the teaching observational data. During these lesson study meetings, the participants revised the research lesson plan before the next iteration of teaching.

Lesson Study Artifacts. During the lesson study, I collected three types of artifacts: revised versions of the research lesson plan, student work, and participant journals. Photographs of the student work were taken after each lesson. These artifacts were collected to provide an in-depth account of student understanding and learning that each lesson provided.

Throughout the stages of the lesson study, the participants completed a reflection journal (see Appendix B). Merriam and Tisdell (2016) noted that personal artifacts, in this case reflection journals, are a reliable source of data concerning a person's attitude, beliefs, and how they view the world. Personal artifacts are highly subjective because the writer is the only one to determine what is considered important to record. The reflection journals captured the

participant’s perspectives or views of the changes toward the CREPS pedagogy, if any. Therefore, the participant’s answers to the reflection questions were vital to answering the research question.

Role of the Researcher

In my role as the researcher, I served as a participant observer. According to Merriam (1998), participant observation is a "schizophrenic activity" (p.103), where the researcher participates in the study, but not to the extent that they cannot observe and analyze. My role as a researcher was to facilitate the lesson study process. I supported and challenged teachers in the processes of reflection related to their practice. As the teachers designed the lesson, my role was to inform and remind teachers of the pedagogical goals needed to execute the CREPS pedagogy. This approach, combined with the teacher's role in observing and evaluating the lesson, led to teachers taking more ownership of the lesson. As the teachers' experience contributed to the lesson they developed, my knowledge of the CREPS pedagogy contributed to the teachers' way of teaching. In addition to improving the lesson design, this collaboration served as a way the CREPS pedagogy could transfer from research to practice.

Data Analysis

Throughout the data collection process, the CREPS pedagogy lens was used to simultaneously conduct preliminary and in-depth analysis of each datum. Analyzing the data simultaneously with collection is sensible and can be informative for researchers (Merriam, 2016). The data collected was analyzed using an inductive approach for a thematic analysis (See Table 20).

Table 20.

Phases of Thematic Analysis

Phase	Description of the process
1. Familiarize yourself with data	Transcribe data, read and actively observe meanings and patterns that appear in the data.
2. Create initial codes	Create a set of initial codes that represent the meanings and patterns seen in the data.
3. Collate codes with supporting data	Bring together all the excerpts associated with a particular code.
4. Group codes into themes	Collate codes into potential themes, gather all data relevant to each potential theme.
5. Evaluate and revise themes	Review and revise themes, ensure that each theme has enough data to support them.
6. Write the narrative	Communicate to readers about the validity of the analysis. Tell a coherent story about the data and choose vivid quotes to back up the points.

Note: From Braun and Clarke (2021).

Following the approach outlined by Braun and Clarke (2021), the lesson study data was analyzed. Upon completion of each iteration of teaching the research lesson, the research lesson plan, observations with comments and annotations and written reflections were included in thematic analysis. Memos were made during the analysis process and used to form thematic codes across the data corpus using In Vivo coding -- a form of qualitative data analysis that places emphasis on the participants' actual spoken words (Saldaña, 2021). This method of data analysis used the participants' words and voice to define key elements of their experiences and perceptions. After the initial coding, the codes were organized, and data used to warrant the formulation of categories. Table 21 provides a sample data excerpt, the In Vivo codes, and the subsequent categories created to illustrate the coding process.

Table 21.

Sample Coded Data Excerpt

Data Excerpt: Oh, I guess what you could do like **a think, pair, share kind of thing**, where students actually kind of **look at the tasks individually before the group talks** about it because sometimes a student won't share their ideas with the whole group if they aren't sure if they are correct or on the right track	
In Vivo Code: A think, pair, share kind of thing	**Category:** Engaging in mathematical discourse
In Vivo Code: Look at the tasks individually before the group talks	

Categories were then grouped together using patterns to develop themes. The themes were evaluated and revised (Braun and Clarke, 2021). This process led to the development of four overarching themes related to the research question. The development of the overarching themes with the corresponding sub-themes are given below (see Table 22). Once the overarching themes were formed, the final analysis and write-up was completed.

Table 22. *Grouping of Categories to Develop Overarching Themes*

Grouping of Categories to Develop Overarching Themes

Categories	**Overarching Themes**
a) Establishing clear mathematics goals to focus learning b) Implementing tasks that promote reasoning and problem-solving c) Supporting productive struggle in learning mathematics d) Eliciting and using evidence of student thinking e) Using and connecting mathematical representations	Development of Deep Understanding
a) Incorporating students' experiences b) Recognizing students' cultural backgrounds	Acknowledgement of Students' Background
a) Posing purposeful questions b) Adopting a collaborative environment that encourages discourse	Employment of Equitable Pedagogical Practices
a) Implementation of the CREPS pedagogy b) Beliefs about the CREPS pedagogy	Transformation of emerging perceptions

Trustworthiness

Several strategies were used to increase trustworthiness for this study. To increase trustworthiness, the researcher included a positionality statement to provide ontological authenticity by revealing the researcher's background and current role (Grant & Lincoln, 2021; Milner, 2007). Next, triangulation was accomplished by using both quantitative and qualitative research designs and by collecting and analyzing multiple data sources. To ensure transferability, the researcher provided detailed descriptions of the participant demographics, the research context, and procedures used to collect the data. Lastly, the researcher viewed the video recordings twice, once to verify the accuracy of the transcripts and another to provide written memos about body language.

Results

Essay three identified instances of effective mathematics teaching when in-service secondary mathematics teachers, with an emergent understanding of the CREPS pedagogy, enact its features through collaborative planning and iterative teaching. This exploratory case study reports on the aspects of the CREPS pedagogy that manifested through the execution of the CREPS pedagogy. The data that was collected consisted of the lesson study meeting recordings, three iterations of recorded research lesson teachings, lesson observations using GoReact with embedded participant comments and annotations, research lesson plans, student work from iterative teachings, and participants’ reflections. The analysis of the data revealed that the participants implementation of the CREPS pedagogy was emergent. There were four themes from the analyses: (1) development of deep understanding of mathematics; (2) acknowledgement of students' backgrounds; (3) employment of equitable pedagogical practices; and (4) transformation of emerging perceptions.

Development of deep understanding of mathematics

One goal of the CREPS pedagogy is to use teaching practices that develop a deep understanding of mathematics. When developing a deep understanding of mathematics, teachers should first identify clear and explicit learning goals. Secondly, teachers should select and implement tasks that promote reasoning and problem solving. The tasks should support students' engagement allowing for productive struggle. Furthermore, the lessons should use evidence of student thinking to assess students' progression of mathematics learning. Finally, lessons should engage students in making connections among the mathematical representations. The analysis produced five sub-themes: (a) establishing clear mathematics goals to focus learning, (b) implementing tasks that promote reasoning and problem-solving, (c) supporting productive struggle in learning mathematics, (d) eliciting and using evidence of student thinking, and (e) using and connecting mathematical representations. Each sub-theme is discussed below.

Establishing clear mathematics goals to focus learning

The execution of the research lessons involved some teaching practices that are necessary to promote deep learning of mathematics. The participants established clear mathematics goals to focus learning. For example, during the development of the first lesson one participant commented, *"In our discussions I believe we talked about being able to establish a learning goal. So, I think that needs to be something in this lesson where, you know, we're intentional about establishing that learning"* (lesson study meeting #2). The goal that was established was - Students will be able to represent a scenario using several representations. The participants told students the lesson's goals in each of the videos of the research lessons. In each video, teachers stated to the students, *"Today, we will represent a practical problem or scenario using different*

representations," prior to beginning the Summer Passes Task. These statements signified the teacher's understanding of the importance of articulating clear learning goals.

Implement tasks that promote reasoning and problem-solving

Participants planned and executed a mathematics lesson that included a RMT. The lesson included a task with a high cognitive demand by supporting students in analyzing and comparing situations. For example, the task required students to analyze and compare several situations by asking them to determine who will be the first one to have enough money to buy the summer pass. In addition, the task required the students to justify or explain their solutions. During the planning of the lesson, the participants were sure to include directions that asked students to explain their reasoning and give evidence of their position. In the video, students were required to provide these explanations on their chart paper and through presentations of their solutions to the class. In addition, the task offered multiple entry points that allowed students with varying skills, knowledge, and levels of confidence to engage with the problem and make valuable contributions. For example, regardless of the students' level, they were able to complete the task. The task also promoted reasoning and sense making. For example, one of the scenarios required students to determine how long it would take to have enough money to buy an $86 summer pass if he earned $10 a day. Students had to reason that to have enough money Donte had to work at least 9 days. If he worked less than 9 days, he would not have enough money to purchase the summer pass. The evidence shows that the participants were aware of the elements needed for a task to promote reasoning and problem-solving.

Support productive struggle in learning mathematics

Each research lesson supported opportunities for students to engage in productive struggle as they learned the mathematics being taught. In each research lesson video, teachers

gave students ample time to complete and struggle through the task. One participant commented, *"I like the fact that students kept working to come up with a representation and did not quit."* Similarly, another participant said, *"And let them figure it out on their own …, sometimes they need to struggle, sweat a little bit and come to some conclusion on what they need to do."* One participant commented on what she learned from observing a lesson, *"And if I don't learn anything from this lesson, I learned how to slow down and let them struggle and come up with their own discovery learning. And they did that in your class."* The students persevered through the task. Overall, the participants learned that it is a meaningful experience when students have time to struggle and not guide them too much through a task.

Elicit and use evidence of student thinking

For each research lesson, the teachers elicited and used evidence of student thinking. Teachers planned to have students present strategies in a sequential order: first the table, then the graph, and the equation would be last. They decided that if any of the representations were not used, the teacher would guide the whole group discussion about that missing representation. In the videos, the teachers selected groups to present their representations on how they determined the answer to the questions. The students presented the strategies they used to solve the problem using varied representations. For example, a group of students represented their solutions using a table of values while other groups used graphs and several groups used equations (see Figure 9). Indeed, participants' meaningful selection and sequencing of students' representation suggested that eliciting and using evidence of student thinking is an important aspect of implementation of the CREPS pedagogy framework.

Figure 10.

Sample Student Work

Use and connect mathematical representations

As the lesson study progressed, the participants began to understand that making connections among mathematical representations is needed to deepen the understanding of mathematics concepts. During the planning session of the first research lesson, the researcher mentioned that after students completed the task, there should be a discussion about the mathematics students should learn about with the representations they will develop. As a group, they decided to focus on appropriate vocabulary as the students analyzed the different representations used to solve the problem. The vocabulary included: (a) rate of change/slope/steepness; (b) y-intercept/initial amount/constant; (c) intersection point; and (d) the slope intercept equation y = mx + b. Some of the research lessons elicited and used evidence of student thinking. In the video of one research lesson, the teacher connected the parts of the mathematical representations with the mathematics vocabulary. For example, as the students presented their representations, one teacher facilitated the dialogue below.

Teacher: "The first group used an equation in the form y = mx + b, what did that m represent?"

Students: The slope.

Teacher: Right… or the rate of change. That number stayed constant. Every day he made $10. Did you find any difference between the Dontae scenario and the Amber scenario?

Students: Amber started with $50, and Dontae started with $0.

Teacher: Yes, she got $50 right off the bat. I remember someone saying it was like a one-time bonus. And each day she was earning…

Students: $1

Teacher: right, $1 a day, what does that 50 represent? If you are thinking about the slope intercept form…

Students: Oh, is it the b?

Teacher: correct, the b. It represents the initial value where she started.

This dialogue shows an example of how the teacher is moving toward teaching *through* problem-solving, a component of the CREPS pedagogy framework, by using and connecting the mathematical representations.

Acknowledgement of students' experiences and cultural backgrounds

Another goal of the CREPS pedagogy framework is for teachers to acknowledge students' experiences and backgrounds so that it can be incorporated into mathematics lessons. Teachers can develop stronger relationships with their students by acknowledging their experiences and cultural backgrounds. The context used in a task must reflect the cultures and interests of the students. The analysis of the data revealed that the lesson study participants acknowledged students' experiences and backgrounds which produced two sub-themes. The sub-themes included (a) incorporating students' experiences, and (b) recognizing students' cultural backgrounds. The sub-themes are discussed below.

Incorporating students' experiences

Participants selected and revised a task so that the context would be relevant to the students' experiences. During the initial planning session, participants created an anticipatory set that included actual amusement parks that their students visit. For example, one participant commented, *"I think we should include the actual amusement parks that our students go to, like Busch Gardens or Kings Dominion."* During the implementation of the lesson, when the participants asked their students about their favorite amusement park, students were very engaged and wanted to participate in the discussion. Another participant felt that since some of their students do not have jobs, they could discuss the ways that they earn money. For example, she asked *"How about asking the students about their experiences with making money?"* The participants agreed on an anticipatory set that showed pictures of two local amusement parks. Then they asked questions like: Which is your favorite? Which one costs more? How much do you think it would cost to go on a trip to this park? What are some ways to earn and save money? The anticipatory set sparked the students' interest by tapping into their prior knowledge about their experiences about amusement parks.

Recognizing students' cultural backgrounds

Not only did participants incorporate students' experiences in the lesson but they also considered their cultural backgrounds in planning the lesson. One participant made a request, *"I want to change some of the names, so they are more diverse."* The participants agreed on the names Dontae, Amber, and Roberto to be more culturally diverse. In addition to changing the names of the students, they suggested including pictures that represented the cultures portrayed in the scenarios. These intentional connections to students' experiences and culture help to support mathematics learning.

Employment of equitable pedagogical practices

As part of the CREPS pedagogy framework, teachers are also encouraged to use equitable pedagogical practices during mathematics instruction. Equitable pedagogical practices include teachers creating classrooms that position students as experts for mathematical problem solving. The analysis of the data revealed that the lesson study participants employed some equitable pedagogical practices, which produced two sub-themes. The sub-themes included (a) posing purposeful questions, and (b) adopting a collaborative environment that encourages meaningful mathematical discourse. The sub-themes are discussed below.

Posing purposeful questions

Participants used purposeful questions to find out what students knew, made connections among mathematical ideas, and revealed student reasoning. For example, during the planning session, one participant suggested,

> Before we put them in groups, if there are students that just don't know how to get started, we could come up with questions or prompts to help them get started. Like, how can you keep track of how much you earn? or how can you represent what you are thinking on paper? And if students finish early, ask, "Can you think of another way to justify your solutions?

The participants planned to ask questions that would assess and advance student thinking while the students were working in their groups. The video shows a teacher asking students to explain and justify their answers. For example, one participant asked, "How did you figure that out," and "How are you representing your thoughts on paper?" As a suggestion for additional teacher moves, one participant gave specific suggestions for the next lesson. She suggested,

> For students who use graphs as a representation, pose questions about whether the graph should be continuous or use discrete points. For students who get their answer using an algebraic representation, we can pose questions about what would happen if the goal was not $89, how can they generalize their algebraic representation for any goal amount.

The participant's suggestion was an attempt to have them extend their thinking by generalizing and making sense of their representation.

Adopting a collaborative environment that encourages discourse

Participants recognized the importance of adopting collaborative learning opportunities that encourage meaningful mathematical discourse. For example, while planning for the research lesson, one participant suggested:

> *I guess what you could do is like a think, pair, share kind of thing, where students actually kind of look at the tasks individually before the group talks about it because sometimes a student won't share their ideas with the whole group if they aren't sure if they are correct or on the right track.*

The Think, Pair, Share strategy is a collaborative learning activity that requires students to think independently before sharing their ideas with their peers. During the lesson observation meeting, one participant said, *"I thought that having the students work individually was good because students then had something to share with their group members, instead of just one person sharing their ideas and the other group members doing as they say."* However, another participant admits that it was a challenge when placing the students in cooperative groups. She explained, *"Students are all different. This is a co-taught (inclusion) class, and some students are afraid to work in groups because of their disability."* Despite the challenges, several participants noted that giving opportunities for students to work individually and collaboratively

was a strength of the lesson. The participants' statements suggested that adopting a collaborative environment that encourages discourse should be a focal point of mathematics instruction.

Transformation of emerging perceptions of the CREPS pedagogy

During the last lesson study meeting, the researcher identified some general themes about the participants' emerging perceptions of the CREPS pedagogy. The themes included (a) implementation of the CREPS pedagogy and (b) beliefs about the CREPS pedagogy. Each sub-theme is discussed below.

Implementation of the CREPS pedagogy

Following the lesson study, the participants reflected on what they learned about the CREPS pedagogy framework. Participants described how their views on mathematics teaching and learning changed after participating in this lesson study. For example, one participant commented on the use of collaborative grouping by stating,

> Prior to COVID, my students were always grouped together. And it was easier for me to have them work in groups. So, I think that what I'm going to do is go back to student grouping…This allows them to actually see and hear other students thinking.

Similarly, another participant stated, "I think it really does build their confidence. I saw it in all the classrooms, they really saw themselves as problem solvers. I think the more we do it, the more confident they're gonna become in their math learning." On the other hand, the other participant shared reflective insight into her views on mathematics teaching and learning,

> I think I will focus more on posing purposeful questions. I think you have to be intentional with that and I don't know if I've always done that. So, that will be something that I could focus on as a goal for myself. Really thinking about the lesson, writing down questions on purpose. That would help facilitate the learning and the discussion. Usually,

> we kind of shoot from the hip a little bit, but I think if you purposefully write them down and make them meaningful… to help guide that discussion, the lesson is more effective.

The participants' reflections suggest that their perceptions about the implementation of the CREPS pedagogy are emerging. The participants' reflections influenced their beliefs about the CREPS pedagogy.

Beliefs about the CREPS pedagogy

In addition, during the final lesson study meeting, participants discussed their beliefs about the CREPS pedagogy framework. One participant responded, “I think it is good to include something students can relate to within the lesson. I believe that when we used Busch Gardens and Kings Dominion in our lesson, that actually allowed the students to relate to the task.” Another participant noted,

> So, I think, the more competent we become with those equitable practices, I really do think that if we begin to implement them, it really does level the playing field for all students. And it was evident in all three classrooms even though some were in AFDA, and some were in different levels of Algebra, all students were able to produce something. They were all able to contribute to the learning. And I think it really does go back to those equitable practices that we put in place. So, I think the more confident we become with it, and the more we implement them, I think the more access we give to all students to participate in the learning.

Further, the other participant stated,

> In our discussion, we mentioned acknowledging their [students] cultural math identity. And so, I really believe that if we do that and we acknowledge their experiences, their

> culture, and how they think about themselves as math students, and in doing that we will enable them to become more confident problem-solvers.

Additionally, after the lesson study, participants completed written reflections on what they now believe to be the meaning of the CREPS pedagogy. One participant explained their meaning as, "tasks and teaching practices that promote a learning environment where all students believe they are contributors to the learning and feel valued in the way they think and engage in mathematics." Another participant noted that the CREPS pedagogy is "a way that we use student experiences to help students to make connections to mathematics concepts." The other participant felt that the CREPS pedagogy is "engaging students in meaningful rich mathematical tasks which allow them to show and communicate their thinking in various ways as well as use mathematics to explore real-world situations that are relevant to their lives and communities." The participants' reflections suggested that the selection of relevant tasks and the mathematical discourse are aspects of the CREPS pedagogy framework.

The participants also reflected on what they believe teachers and students should be doing during the implementation of the CREPS pedagogy. One participant stated that,

> Teachers should provide a learning environment and opportunities for all students to engage in the learning of mathematics. Teachers should be facilitators as students engage in the learning process by supporting deep learning and valuing students' thinking and experiences as they communicate their ideas in a collaborative setting.

Another participant noted that, "Teachers should be asking purposeful questions to assist student learning. Provide students with time to problem solve as well as not to direct the path of students." In addition, the last participant wrote, "Teachers should serve as facilitators of the

learning process, affirm strategies that promote mathematical discourse and not just yield correct answers."

When asked to provide a statement about what they believe students should be doing during the implementation of the CREPS pedagogy, one participant explained that "Students should have time to think individually, then share their methods for solving a problem with a partner." Similarly, another participant said, "Students should be communicating with each other and listening to others' opinions or strategies to solve the task." Another participant wrote, "Students should engage in mathematics in a meaningful way. They should be leading discussions, making connections, reasoning, reflecting on their learning, and applying their learning to situations outside of the classroom." The participants' descriptions clearly showed that collaboration and students' mathematical discourse is important when implementing the CREPS pedagogy framework.

Discussion

This section begins with an overview of the purpose of this study, the research question, and a discussion of the findings. The section concludes with a discussion of the limitations of the study and implications for practice and future research.

Research Overview

The purpose of this research is to explore ideas of how to improve Black students' opportunities to engage in effective mathematical problem solving to improve their mathematics understanding and achievement. This case study captured effective examples of the CREPS pedagogy framework when it was being enacted by secondary mathematics teachers with emergent CREPS pedagogical knowledge. The following research question guided this case

study: How do in-service secondary mathematics teachers, with an emergent understanding of the CREPS pedagogy, enact its features through collaborative planning and iterative teaching?

Discussion of Findings

Although the lesson study approach was used in this study, it is not the focus of the research study. It served as a vehicle for gathering data about the execution of the CREPS pedagogy framework. Therefore, the focus is not on the comparison of each lesson iteration but rather identifying strong moments of effective teaching practices that are representative of the CREPS pedagogy framework. Three examples of these moments from the research lessons are described below. It should be noted that the order in which they are described is not indicative that one is better than the other.

The facilitation of meaningful mathematical discourse that occurred because of the implementation of the CREPS pedagogy framework is an example of effective teaching practices. Smith and Stein (2018) described five practices that were designed to help teachers orchestrate a productive student discussion of various solutions representing students' mathematical thinking. The research lessons included several of these practices. To orchestrate productive mathematical discussions, it is helpful to anticipate likely student responses to challenging mathematical tasks. For example, the participants planned to ask questions that would assess and advance student thinking while the students were working in their groups such as "How did you figure that out?" and "How are you representing your thoughts on paper?" As students work on the tasks in pairs or small groups, monitoring their responses can assist in facilitating productive mathematical discussions. In the video, participants circulated around the classroom while students worked in their groups. They paid close attention to the students' mathematical thinking and solution strategies as they worked on the task. When orchestrating

productive mathematical discussions, teachers should select particular groups of students to present their mathematical work during the whole class discussion. For example, in the videos, the teachers selected three groups of students to present how they represented their solutions. There was one group of students for each desired representation. Once students are selected, mathematical discussions can be orchestrated more effectively by sequencing the student responses in a specific order. The selected groups presented their representations in a sequential order: first the table, the graph, and then the equation. They decided that if any of the representations were not used, the teacher would guide the whole group discussion about that missing representation. The last effective way of orchestrating productive mathematical discussions involves connecting different students' responses to key mathematical ideas. For example, after the student presentations, teachers used the representations to connect the common mathematical vocabulary that is represented in each solution.

The selection of tasks that promote reasoning and problem-solving is another example of an effective teaching practice that represents the CREPS pedagogy framework. One of the roles of mathematics teachers is to select or develop worthwhile or genuine problems (Boaler, 2016; Cai, 2003; King, 2019; Lester 2013; Lester & Cai, 2015; Smith & Stein, 2018; Van de Walle et al., 2018). For this study, we refer to these types of tasks as rich mathematical tasks (RMT). In this study, teachers selected a mathematical task (see Appendix J) that had a high level of cognitive demand. Students were given three scenarios and asked, “If a summer pass to Busch Gardens costs $86, who will be the first one to have enough money to buy the pass? How long will it be before they can all go together?” The task required students to analyze and compare mathematical situations. In addition, the task required students to justify, reason, and make sense of their solutions. The task asked, “Explain your reasoning and give evidence of your position.”

When selecting a task that promotes problem-solving, researchers suggest that it offer multiple entry points allowing students with varying skills, knowledge, and levels of confidence to engage with the task and make valuable contributions. The task selected for this study allowed students to engage in the task that made more sense to them, rather than trying to replicate a procedure that was shown to them. In addition, the tasks should be relevant and reflect the students' interest. For this study, participants selected an amusement park-related task. It is common for students in this age group to be familiar with and enjoy amusement parks. Engaging students in everyday situations that are relevant to them increases their participation, increases their use of problem-solving strategies, and makes them more productive (Van de Walle et al. 2018).

In addition to selecting appropriate tasks, developing cultural awareness and acknowledgment of cultural differences is the last example of an effective teaching practice that represents the CREPS pedagogy. Being culturally responsive, which is a component of the CREPS pedagogy, starts with cultural awareness and acknowledging cultural differences. Teachers who are culturally aware keep their students' cultures in mind and take care to honor and respect their home cultures in their daily interactions and instruction. (Gay, 2010; Koonce, 2018; Ladson-Billing, 1994; Thomas & Berry, 2019). As I mentioned in the last example, choosing the right task is important but it is also important to adapt it to make it culturally diverse. For this study, participants adapted the task so that it was culturally appropriate. Researchers agree that adapting tasks to be culturally relevant creates a bridge between students' backgrounds and mathematics understandings (Aguirre et al., 2013; Gay, 2010; Ladson-Billings, 1994). They changed the names to Dontae, Amber and Roberto to be more culturally diverse. In addition to changing the names of the students, they included pictures that represented the cultures portrayed in the scenarios. In this study, participants developed cultural awareness

through multiple means, including reflection, having an open mindset to learning, and engaging in collaborative conversations with their colleagues. Consequently, one might conclude that engaging teachers in the pedagogical goals of the CREPS pedagogy supports their emergent understanding of the synergistic relationship of those components as a comprehensive framework for problem-solving.

Limitations

There are several limitations to this investigation, the primary one being the generalizability of the results. Case studies do not lend themselves to generalizations because what happened in these three instances of teaching would not be sufficient evidence for predicting across many (Merriam, 1998; Stake, 1995; Yin, 2018). Replications of this study should include more than one lesson study group to effectively capture the CREPS pedagogy teaching practices. There are some other factors to consider that may have improved the results of this study. Although lesson study was only used as a vehicle for conducting the study, it rendered another limitation. The researcher was inexperienced in conducting lesson studies. This inexperience could have contributed to the slight variance when compared to traditional lesson studies. The last limitation was the time of the school year this study was conducted. The data was collected after spring break but before the end of year testing. Due to the pressure of preparing for the end of year assessment, the time that this study was conducted could have influenced the participants' level of involvement with implementing the execution of the research lessons.

Implications for Practice

The results of this study have implications for practice. The participants in this study were provided professional development on the CREPS pedagogy framework before

participating in this study; therefore, their understanding of the CREPS pedagogy was emergent. As teachers' understanding of the CREPS pedagogy emerges, the next step would be classroom implementation. In my opinion, it is more powerful to be able to observe the CREPS pedagogy in action than to read about it or hear about its implementation. I recommend that teachers observe someone who has experience and success implementing the CREPS pedagogy. After identifying the CREPS pedagogy model teachers, teachers should be provided with time to observe colleagues' implementation. Through such professional development opportunities, teachers can observe and learn what the CREPS pedagogy looks like when implemented. Such understanding has the potential to lead more teachers successfully implementing the CREPS pedagogy.

Recommendations for Future Research

Teachers would likely benefit from engaging in professional learning that includes collaborative and iterative teaching experiments using CREPS pedagogy. For example, teachers' implementation of CREPS pedagogy using lesson study would afford teachers and researchers insights about both teachers' and students' experiences in relation to mathematics learning. Potential research questions might include: What is the nature of Black learners' mathematics engagement and discourse during a CREPS pedagogy lesson? What types of questions were posed during a CREPS pedagogy lesson and how do they compare to other mathematics lessons? Lastly, it is recommended that further research examine the academic outcomes of Black students when their teachers effectively teach mathematics using CREPS pedagogy.

Conclusions

Historically, Black students in K-12 classrooms have been underserved which has caused them to struggle to achieve at the same level as their white peers in the mathematics classroom.

In response to these mathematics disparities, examining the pedagogical practices of educators has been identified to narrow this gap. The purpose of this study is to capture effective examples of the CREPS pedagogy when it is being enacted through the lens of teachers whose CREPS knowledge is emerging. This study identified strong moments of effective teaching practices that are representative of the CREPS pedagogy. One moment included the facilitation of meaningful discourse between peers and with the teacher. Another moment was the selection of tasks that promote reasoning and problem-solving. The last moment included developing cultural awareness and acknowledgement of cultural differences. Therefore, I conclude that teachers should be provided with time, space and resources to implement CREPS in their mathematics instruction.

CHAPTER 5

CONCLUSION

The final chapter of this dissertation presents my conclusions about the research presented. The conclusion begins with a discussion of the significance of the problem being addressed. In summarizing the findings for each essay, I will emphasize how that essay contributes to the field of mathematics education's understanding of the teaching and learning of Black students. Furthermore, I will synthesize the important ideas across the essays. The final section of this chapter concludes with some implications and recommendations.

Significance of Problem Addressed by this Dissertation

The significance of this research study is that it will contribute to the body of work surrounding the teaching and learning of mathematical problem solving to Black students in efforts to close the achievement gap by providing opportunities. With the publication of *The Brilliance of Black Children in Mathematics: Beyond the Numbers and Toward New Disclosure* (Leonard & Martin, 2013), there has been a boost in research in mathematics education devoted to unpacking the teaching practices needed to teach Black students. Rather than blaming students, their families, or their communities, this publication identifies outside factors that sustain Black students' systematic marginalization. In addition to this publication, Martin (2019) asserted,

> I suggest that those who believe in the humanity of Black people actively resist and reject mathematics education that results in epistemological violence and mathematics reforms that perpetuate antiblackness. … Instead, research in service to acknowledge and valuing Black humanity can start with the axiom of Black learners' brilliance.

Martin (2019) supports disrupting normative discourses about Black students and mathematics. I assert that mathematics education researchers that are interested in studying teaching practices that help Black students begin from Martin's standpoint of Black learners' brilliance coupled with a framework conceptualized for Black students. I offer the CREPS pedagogy, my theoretical conceptualization that connects black culture, equity, and mathematical problem-solving.

This research study has benefits to both students and teachers. The first benefit of this study is that teaching using the CREPS pedagogy in mind capitalizes on students' funds of knowledge by providing students with the opportunity to relate the learning of mathematics to their cultural background knowledge which assists students in developing their cultural identities and perceptions of themselves as capable learners of mathematics. Another benefit of this study is that teaching using the CREPS pedagogy encourages the use of higher-level thinking skills that involve analyzing, reasoning, and evaluating by preparing them to use multiple strategies to solve problems and justify their solutions. Another benefit of this study is that teaching using the CREPS pedagogy practices ongoing self-reflection and teacher examination of their own beliefs, values, and perceptions about race, ethnicity, and culture and how they intertwine to shape their students' learning experiences.

This research also has the potential to influence organizations and interested parties to creatively approach culturally responsive equitable problem-solving pedagogy as a systematic change. Policymakers need to recognize the significance and the benefits of culturally responsive equitable problem-solving pedagogy by creating policy that favors culturally responsive mathematics teaching. There is a need to develop teachers who include culturally responsive equitable problem-solving pedagogy as a part of the practices when teaching Black students.

These pedagogical practices can be continued during in-service teaching by providing annual culturally responsive mathematics professional development. Subsequently, leadership will have to support teachers in making changes in how mathematics is taught to Black students. Pushing for change in how teachers are prepared to teach mathematics can help foster environments for Black students to achieve.

Essay Summaries

The three essays contained within this dissertation explored the development, conceptualization, and enactment of the conceptual framework, the CREPS pedagogy, respectively. The CREPS pedagogy consists of the intersection of three pedagogical ideas: Gay's (2002) Culturally Responsive Pedagogy (CRP), Aguirre, Mayfield-Ingram, Martin's (2013) Equity-Based Mathematics Practices (EBMP), and Schroeder and Lester's (1989) Teaching *through* Problem-Solving (T*t*PS). Below is a summary of each essay.

The first essay introduces and describes the conceptual framework for the study. The purpose of this essay is to explore how education scholars have discussed the intersection of CRP, EBMP, and T*t*PS in mathematics classrooms to situate and position a conceptual framework for developing teaching practices that infuse the CREPS pedagogy. Because this is my novel conception of a pedagogy for Black children, there is no research focused on the integration of these three pedagogies. Therefore, this presents a void in the literature, therefore the integration of the three approaches as a conceptual framework, CREPS pedagogy, is proposed. The implementation of CREPS consists of three pedagogical moves: (a) development of deep mathematics understanding; (b) acknowledgement of students' backgrounds; and (c) employment of equitable pedagogical practices. An implication for essay one is for school districts to provide continued professional development for supporting teachers in creating

mathematics classrooms that implement CREPS pedagogy. By providing professional development, teachers would be able to understand CREPS pedagogy and through understanding CREPS pedagogy, teachers will be more responsive to Black students' mathematical problem-solving achievement.

Essay two employed a mixed methods methodology, whose purpose was to help teachers conceptualize the CREPS pedagogy. There were three goals for this study. The first goal was to understand secondary mathematics teachers' perceptions of their readiness for CRP. Another goal was to see if their perceptions of their readiness aligned with their application of CRP during the professional development. The last goal was to determine how to prepare secondary mathematics teachers to understand the CREPS pedagogy. Analysis of the data from the CRTRS indicated how teachers perceived their readiness to teach in a culturally responsive way. Participants' ($N = 51$) mean overall scores on the CRTRS were relatively high ($M = 4.06$), which shows that in-service secondary mathematics teachers who participated in the survey perceived themselves as ready to teach in a culturally responsive way. In addition, analysis of the data generated from 10 secondary mathematics teachers who attended the professional development revealed three overarching themes: (1) establishing a meaning of culturally responsive mathematics teaching, (2) navigating an understanding of the CREPS pedagogy, and (3) connecting with components of the CREPS pedagogy. Overall, the analysis of the data indicated that teachers had an emergent understanding of CREPS pedagogy.

Essay three used a case study research design that captured effective examples of the CREPS pedagogy when it is being enacted through the lens of teachers whose CREPS knowledge is emerging. The goal for this study was to explore the execution of the CREPS framework situated in the lesson study process. The analysis of the data from the lesson study

revealed four overarching themes: (1) development of deep understanding of mathematics; (2) acknowledgement of students' backgrounds; (3) employment of equitable pedagogical practices; and (4) transformation of emerging perceptions. Overall, the analysis of the data revealed that teachers were on the verge of full implementation of the CREPS pedagogy.

Syntheses across the Essays

The focus of this section is on what can be learned from synthesizing findings from the three essays about the CREPS pedagogy. The first essay identified and described three pedagogical moves that are necessary for successful implementation of the CREPS pedagogy. The three pedagogical moves include: (a) development of deep mathematics understanding; (b) acknowledgement of students' backgrounds; and (c) employment of equitable pedagogical practices. The synthesis is organized to include the three pedagogical moves, providing a brief explanation of the moves from essay one and then discussing what additional insights essay two and essay three contribute.

Developing deep mathematical understanding is a pedagogical move needed for full implementation of the CREPS pedagogy. As described in essay one, developing deep mathematical understanding should incorporate mathematics lessons that include high cognitive demand tasks that promote reasoning and problem-solving, including multiple entry points and solution strategies, varied representations and require explanation, justification or proof. In essay two, participants analyzed sample tasks to identify their characteristics, determined which characteristics were needed to constitute a RMT, and then engaged in completing a RMT. Using their knowledge of the characteristics of RMTs, in the essay three participants selected, adapted and implemented a RMT in their mathematics lesson.

Acknowledging students' backgrounds is another pedagogical move needed for full implementation of the CREPS pedagogy. The first essay described acknowledging students' backgrounds as mathematics lessons that incorporate students' cultural and mathematical backgrounds as well as their experiences that shape their identity. In essay two, participants described being culturally responsive as being aware of the students' culture, backgrounds and experiences. As a result of essay two, participants applied their knowledge of incorporating students' experiences into mathematics classes in essay three by using the anticipatory set to spark the students' interest by tapping into their prior knowledge about their experiences about amusement parks. In addition, participants changed the names of the characters and the picture used in the task to reflect their students' cultural backgrounds. These intentional connections to students' experiences and culture help to support mathematics learning.

Employing equitable pedagogical practices is the last pedagogical move needed for full implementation of the CREPS pedagogy. The first essay described employing equitable pedagogical practices as mathematics lessons that include collaboration and meaningful discourse amongst all learners (i.e., peers and teachers). In essay two, participants recognized the importance of embedding collaborative learning opportunities in their mathematics classrooms. As a result of essay two, participants applied their knowledge of employing equitable pedagogical practices by incorporating purposeful questioning and adopting a collaborative learning environment.

A major concern in the mathematics education of students has been how to address the achievement gap between Black and white students. Historically, Black students in K-12 classrooms have been underserved which has caused them to struggle to achieve at the same level as their white peers in the mathematics classroom. The CREPS pedagogy was developed in

response to this concern. The findings of the essays revealed that engaging teachers in the components and the pedagogical moves of the CREPS pedagogy supports their emergent understanding of the synergistic relationship of those components as a comprehensive pedagogy for mathematical problem-solving.

Implications of CREPS Pedagogy for Mathematics Teaching

Teachers must consider culture, equity, and problem-solving when developing and executing mathematics lessons for Black students. The CREPS pedagogy provides a framework for teachers to consider using when developing and implementing mathematics lessons. Among the practical implications would be to ensure that teachers have a thorough understanding of what the CREPS pedagogy is and how it should be implemented in mathematics classrooms.

Professional learning plays an important role in the professional growth of teachers (Darling-Hammond et al., 2017). Although it is essential to improving student outcomes, it gets a bad rap, but for good reason. All sides of the education reform and improvement debate agree that many professional learning opportunities for teachers are infrequent, sparse, and of little use in improving teaching (Hill, 2009). School districts should provide continued professional development for supporting teachers in creating mathematics classrooms that implement the CREPS pedagogy. By providing professional development, teachers would be able to understand CREPS. Through understanding CREPS, teachers will be more responsive to Black students' mathematical problem-solving achievement.

As teachers' level of understanding of the CREPS pedagogy develops, the professional development should be customized to meet their needs. When teachers participate in ongoing professional development on the CREPS pedagogy, they could serve as support for others who are trying to implement it in their instruction. For teachers to be able to effectively implement the

CREPS pedagogy, they must be provided with opportunities to learn about, implement and reflect upon the pedagogy. Although teachers are provided with planning periods during the school day, this time is minimal. Currently, teachers are not afforded ample opportunities or time to collaborate with other teachers to plan for mathematics instruction. Once teachers are provided professional development on the CREPS pedagogy, more time will be needed to plan for implementation. Therefore, another implication is to provide teachers with the ample opportunity and time to work together to develop lessons that infuse the CREPS pedagogy.

As teachers' understanding of the CREPS pedagogy emerges, the next step would be classroom implementation. In my opinion, it is more powerful to be able to observe CREPS in action than to read about it or hear about its implementation. I recommend that teachers observe someone who has experience and success implementing the CREPS pedagogy. After identifying CREPS model teachers, teachers should be provided with time to observe colleagues' implementation. Through such professional development opportunities, teachers can observe and learn what CREPS looks like when implemented. Such understanding has the potential to lead more teachers successfully implementing CREPS.

Recommendations for Future Research

Because CREPS pedagogy is an original conception, designed by a Black scholar for Black children, there are several opportunities for further research. For example, there is a need to explore the fidelity of the CREPS pedagogy conceptualization that emerged from this synthesis of CRP (Gay, 2002), equity-oriented practices (Aguirre et al., 2013), and teaching *through* problem solving (Schroeder & Lester, 1989). Potential research questions to consider: What is the CREPS pedagogy missing for effectively engaging Black mathematics learners? What aspect, if any, of the CREPS pedagogy has been undertheorized? To support teachers'

adoption of CREPS pedagogy for mathematics teaching will require affording them opportunities to engage in professional learning involving collaborative and practice-centered experiences (Akiba et al, 2019; Dudley et al., 2019; Murata et al., 2012; Takahashi et al., 2013). A recommendation for developing teachers' CREPS pedagogical knowledge is to afford them opportunities to participate in engaging in CREPS pedagogy as learners to introduce the CREPS pedagogy. Additionally, teachers would likely benefit from engaging in professional learning that includes collaborative and iterative teaching experiments using CREPS pedagogy. For example, teachers' implementation of CREPS pedagogy using lesson study would afford teachers and researchers insights about both teachers' and students' experiences in relation to mathematics learning. Potential research questions might include: What is the nature of Black learners' mathematics engagement and discourse during a CREPS pedagogy lesson? What types of questions were posed during a CREPS pedagogy lesson and how do they compare to other mathematics lessons? Lastly, it is recommended that further research examine the academic outcomes of Black students when their teachers effectively teach mathematics using CREPS pedagogy. These recommendations for further research are just the tip of the iceberg of investigation into the CREPS pedagogy.

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APPENDIX A

OFFICE OF THE VICE PRESIDENT FOR RESEARCH

Physical Address
4111 Monarch Way, Suite 203
Norfolk, Virginia 23508
Mailing Address
Office of Research
1 Old Dominion University
Norfolk, Virginia 23529
Phone(757) 683-3460
Fax(757) 683-5902

DATE: January 24, 2023

TO: Melva Grant
FROM: Old Dominion University Education Human Subjects Review Committee

PROJECT TITLE: [1849726-1] Exploring Math Teacher's Culturally Responsive Mathematics Teaching through Problem-Solving
REFERENCE #:
SUBMISSION TYPE: New Project

ACTION: DETERMINATION OF EXEMPT STATUS
DECISION DATE:

REVIEW CATEGORY: Exemption category #2

Thank you for your submission of New Project materials for this project. The Old Dominion University Education Human Subjects Review Committee has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact John Baaki at (757) 683-5491 or jbaaki@odu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Old Dominion University Education Human Subjects Review Committee's records.

APPENDIX B

Norfolk Public Schools
The cornerstone of a proudly diverse community

November 10, 2022

Ms. Tisha Jones
Doctoral candidate, Old Dominion University
tjones266@nps.k12.va.us

Approval is granted to conduct the proposed research project, *Exploring Math Teacher's Culturally Responsive Mathematics Teaching through Problem-Solving*, in fulfillment of the capstone project requirement for the degree of Doctor of Education from Old Dominion University. The proposed research project meets the technical criteria following the Norfolk Public Schools Research and Survey Policy (www.nps.k12.va.us) and must follow the stipulations below:

- Norfolk Public Schools will NOT provide the email addresses, nor phone numbers, of the administrators and teachers, at the schools.
- Voluntary participation allows each participant to decide individually whether to participate or withdraw at any time, without question, consequence, or follow-up.
- **All participants, and Norfolk Public Schools, will remain anonymous in data and survey collection, and reporting results**. Identifiable characteristics or linkage to the identity of any individual, school, or school district is prohibited.
- Approval does not constitute commitment of resources or the endorsement of the study or its findings by the school district or the School Board.
- Data collected and results will not become part of any principal, school, or district record. All research records must be locked in a secured location.
- The researcher will email a copy of the final report for the school district, and report any changes or problems while conducting the study, to Dr. Bailey.

We look forward to your findings and contribution to instructional practice, program services, and achievement for *ALL* students.

Sincerely,

Karren P. Bailey

Karren P. Bailey, Ed.D.
Sr. Director, Research & Program Evaluation
Email: Kbailey1@nps.k12.va.us

Michael Cataldo

Michael Cataldo, Ed.D.
Chief Information & Instructional Technology Officer
Email: mcataldo@nps.k12.va.us

APPENDIX C

Survey - Interest Email

Subject: You are invited to participate in a survey – "Culturally Responsive Teaching Readiness Survey"

Greetings!

You are invited to participate in a survey about Culturally Responsive Teaching Readiness and at the end of the survey you will be asked if you are interested in learning more about participating in a research study entitled "Exploring Math Teacher's Culturally Responsive Mathematics Teaching *through* Problem-Solving". This study is being conducted by Tisha Jones as part of her doctoral dissertation in Curriculum and Instruction from Old Dominion University and approved by Norfolk Public Schools. More information about the research study will be described in the survey before you decide to participate.

Your participation in this Culturally Responsive Teaching Readiness survey is voluntary and you can stop taking the survey without penalty at any time. The survey should take about 15 minutes to complete.

This survey has been approved by the Department of Teaching and Learning Institutional Review Board at Old Dominion University (ODU) and Norfolk Public Schools (NPS). There are no risks associated with participating in this survey.

The survey will be anonymous and if you choose to participate your email address will be entered into a raffle to win one of four $25 Amazon *e*Gift cards. However, your email address will be captured by Qualtrics as proof of consent, but it will be kept separate from your survey responses to ensure your anonymity.

While you will not experience any direct benefits from participation, information collected in this study may benefit the profession of teaching in the future by better understanding whether NPS secondary mathematics teachers and mathematics special education teachers believe they are ready to teach culturally responsive pedagogy.

If you have any questions regarding the survey in general, please contact Tisha Jones at 757-579-9820 or tn026@odu.edu.

By choosing "Yes" you are indicating your consent to participate in the survey.

Thank you,

Tisha Jones, Doctoral Student, Curriculum and Instruction, Old Dominion University
Advisor: Dr. Melva Grant, Department of Curriculum and Instruction, Old Dominion University

Please click on the survey link below and provide us with your feedback no later than February 22, 2023.

Link to Culturally Responsive Teaching Readiness Survey

APPENDIX D

Informed Consent – Survey

Culturally Responsive Teaching Readiness Survey Instrument with Consent

Q0. INFORMED CONSENT for Culturally Responsive Teaching Readiness Survey by Karatas & Oral (2017) gives you information that may affect your decision whether to say YES or NO to participate in this research, and to record the consent of those who say YES.

RESEARCHERS

Melva R. Grant, Ph.D., Responsible Project Principal Investigator, Professor of Mathematics Education, Darden College of Education & Professional Studies, Department of Teaching & Learning

Tisha Jones, Student Investigator, Curriculum and Instruction Doctoral Student, Darden College of Education & Professional Studies, Department of Teaching & Learning

DESCRIPTION OF RESEARCH STUDY

You are invited to participate in a research study about culturally responsive mathematics teaching through problem-solving, an equity-oriented mathematics teaching approach. The continued inequitable practices present in K-12 mathematics teaching in the United States suggest that more research is needed to determine what it means to be a culturally responsive mathematics teacher and how to integrate it with teaching through problem-solving. Despite a great deal of research in mathematics education about culturally responsive pedagogy and problem-solving, researchers know little about the potential for culturally responsive mathematics teaching through problem-solving and its influence on students' engagement, dispositions, and mathematics learning. The purpose of this survey is to determine the readiness level for culturally responsive teaching. You will be asked questions that will assess your culturally responsive teaching readiness.

We are asking consent to take the Culturally Responsive Teaching Survey. Potential participants include secondary mathematics teachers and mathematics special education teacher collaborators who are employed by Norfolk Public Schools. Participants who complete the survey will be entered into a raffle to win one of four $25 Amazon e-Gift Cards.

If you choose **YES** (consent), you will be asked to provide an email address so we can send you a copy of this information for your records and then you may begin the survey. We will also keep a record of your email as evidence of your choice to participate, but it will be separate from your responses so that your anonymity is maintained. Once you start the survey, you can choose to stop taking it at any time with no negative consequences. If you choose **NO** (not to consent), we will not request your email address or proceed to the survey. Once the survey is completed you will have the opportunity to decide if you want to participate in the professional development sessions and the lesson study.

If you have question about the Culturally Responsive Teaching Survey, contact the Principal Investigator, Dr. Melva Grant mgrant@odu.edu at (757)683-5725 or the Student Investigator, Tisha Jones tn026@odu.edu at (757)….

RISKS AND BENEFITS

RISKS: If you decide to participate in this study, then you may face a risk that a release of confidential information can occur. However, the surveys are administered using online software that protects all identifying information for respondents. If you choose to provide information for future contact, the information is not connected to any individual survey responses and cannot be connected manually by the researchers. There is no risk of association between these data because of the technology being used for survey administration. As with any research, there is some possibility that participants may be subject to risks that have not yet been identified.

BENEFITS: There are no direct benefits for the participants.

COSTS AND PAYMENTS
The researchers want your decision about participating in this study to be voluntary. The researchers are unable to give you any payment for participating in this survey.

NEW INFORMATION
If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY
The survey is anonymous, meaning that your responses are not connected to you. Individual responses are confidential, meaning that no one will know how an individual responded. If a response includes identifying information, it will not be shared publicly.

WITHDRAWAL PRIVILEGE
It is OK for you to say NO (not consent) to taking the survey. Even if you say YES now, you will have the option to say NO and not participate in the survey or stop the survey at any time and there are no negative consequences. A NO decision by you will not affect your relationship with Old Dominion University, or otherwise cause a loss of benefits to which you might otherwise be entitled.

COMPENSATION FOR ILLNESS AND INJURY
If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of harm or injury rising from this study, neither Old Dominion University nor the researchers can give you any money, insurance coverage, free medical care, or any other compensation for such injury. If you suffer injury because of participation in this research project, you may contact the Responsible Principal Investigator, Dr. Melva Grant at 757-683-5725, Dr. John Baaki the current IRB chair at 757-683-5491 at Old Dominion University, or the Old Dominion University Office of Research at 757-683-3460 who will be glad to review the matter with you.

VOLUNTARY CONSENT
By choosing YES (consent), you are saying several things. You are saying that you have read this information, that you are satisfied, that you understand this information, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions later, about the study, contact the Responsible Principal Investigator, Dr. Melva Grant mgrant@odu.edu at 757-683-5725 or the student investigator Tisha Jones tn026@odu.edu at 757-683-5725, Dr. John Baaki, the current IRB chair, at 757-683-5491, or the Old Dominion University Office of Research, at 757-683-3460. By choosing NO your decision is to exit now without participating in the survey.

Please make your selection:

☐ YES - If yes the survey will continue.

☐ NO - If no the survey will skip to the end of survey.

APPENDIX E

Survey – Demographics

Q. Please enter your email address. _____

We will email the informed consent information to you for your records. The researcher will retain your email address as evidence of your participation but will not contact you unless you choose to allow it. Your email address is not connected to your responses to this survey to maintain your anonymity. In addition, your email address will be used to enter you into the raffle to win one of four $25 Amazon gift card. The drawing will be done at the end of this month. If you win, you will receive an email with instructions on how to claim your prize.

Demographic Information:

Q. Describe your gender. _____ Female _____ Male _____ Other

Q. Describe your age.
_____ Under 25
_____ 25 – 29 years old
_____ 30 – 34 years old
_____ 35 – 39 years old
_____ 40 – 44 years old
_____ 45 – 49 years old
_____ 50 years old or older

Q. Describe your teaching context
_____ Middle School
_____ High School

Q. Describe your teaching experience.
_____ Under 5 years
_____ 6 to 10 years
_____ 11 to 15 years
_____ 16 to 20 years
_____ over 20 years

Q. Describe your race or ethnicity.
_____ White
_____ Black or African American
_____ American Indian or Alaska Native
_____ Asian
_____ Native Hawaiian or Pacific Islander
_____ Other

Q. In your current professional employment, which of the following roles do you perform most?
_____ Mathematics Teacher
_____ Special Education Teacher for Mathematics
_____ Other

End of Demographics

Begin Culturally Responsive Teaching Readiness Survey

APPENDIX F

Survey

Select your level of agreement.

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
1. I am ready to teach in a class where there is cultural diversity.	○	○	○	○	○
2. I am curious about cultural values of the students in my class.	○	○	○	○	○
3. I think that while I guide my students' learning, I need to consider their cultural values. 3	○	○	○	○	○
4. I enjoy interacting with people from different cultures.	○	○	○	○	○
5. I do not tolerate students in my class to discriminate against each other because of their cultural diversity.	○	○	○	○	○
6. I think it would be fun to train in a class where cultural diversity is experienced.	○	○	○	○	○
7. My university instructors created awareness of the cultural diversity during my undergraduate or graduate education.	○	○	○	○	○

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
8. When cultural diversity is taken into consideration, I can teach anywhere in the United States.	○	○	○	○	○
9. I would like to increase the interactions in and out of the classroom by learning vocabulary and sentences from the mother tongues of my non-English native speakers.	○	○	○	○	○
10. I think that the compulsory courses I have taken during undergraduate and/or graduate education have contributed to me in terms of sensitivity to cultural values.	○	○	○	○	○
11. I find my undergraduate and/or graduate education program sufficient in creating awareness about cultural diversity in the U.S.	○	○	○	○	○
12. I think that students should be encouraged to give examples specific to their own culture during the lessons.	○	○	○	○	○
13. I think that having training by taking the cultural environment in which the students are brought up into account will increase students' academic achievement.	○	○	○	○	○
14. I gained an awareness of the cultural diversity that lives on the geography of the U.S. during my undergraduate and/or graduate education.	○	○	○	○	○

	Strongly agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Strongly disagree
15. I obtained information to know different cultures in the US during my undergraduate and/or graduate education.	○	○	○	○	○
16. If I have an option, I will teach in a place where people have different cultural characteristics different from my own culture.	○	○	○	○	○
17. I believe that our educational system should be structured to reflect the cultural diversity from pre-school to the university.	○	○	○	○	○
18. I am aware that students' cultural lives must be used as a means of achieving their learning objectives.	○	○	○	○	○
19. I find textbooks taught in undergraduate and/or graduate education courses sufficient in terms of presenting information related to cultural diversity.	○	○	○	○	○
20. I think elective courses I have taken in undergraduate and/or graduate education period have contributed to me in terms of sensitivity to cultural values.	○	○	○	○	○
21. I have gained awareness of cultural diversity thanks to the involvement of education instructors' personal lives and experiences.	○	○	○	○	○

APPENDIX G

Informed Consent – Professional Development

INFORMED CONSENT DOCUMENT
OLD DOMINION UNIVERSITY

PROJECT TITLE: Exploring Math Teachers' Culturally Responsive Mathematics Teaching *through* Problem-Solving

INTRODUCTION
The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participate in this Professional Development on Culturally Responsive Mathematics Teaching *through* Problem Solving and to record the consent of those who say YES.

RESEARCHERS
Melva R. Grant, Ph.D., Responsible Project Principal Investigator, Professor of Mathematics Education, Darden College of Education & Professional Studies, Department of Teaching & Learning
Tisha Jones, Student Investigator, Curriculum and Instruction Doctoral Student, Darden College of Education & Professional Studies, Department of Teaching & Learning

DESCRIPTION OF RESEARCH STUDY
You are invited to participate in professional development about culturally responsive mathematics teaching *through* problem-solving, an equity-oriented mathematics teaching approach. The continued inequitable practices present in K-12 mathematics teaching in the United States suggest that more research is needed to determine what it means to be a culturally responsive mathematics teacher and how to integrate it with teaching *through* problem-solving. Despite a great deal of research in mathematics education about culturally responsive pedagogy and problem-solving, researchers know little about the potential for culturally responsive mathematics teaching *through* problem-solving and its influence on students' engagement, dispositions, and mathematics learning. The purpose of this professional development is to inform and improve the knowledge and skills of secondary mathematics teachers to facilitate the implementation of culturally responsive mathematics teaching *through* problem-solving.

Participants include secondary mathematics teachers and special education teacher collaborators who are employed by Norfolk Public Schools. If you decide to participate, this professional development will last approximately 3 hours. Norfolk Public Schools employees will receive professional development hours for your participation. Your participation in this professional development is voluntary.

Once the professional development is completed, you can decide if you want to further participate in the lesson study.

RISKS AND BENEFITS
RISKS: The researchers are trying to capture your thoughts and perspectives about culturally responsive mathematics teaching, teaching through problem-solving, and participating in a lesson study. Your discussions and responses during the professional development session will be recorded by audiotape and kept confidential. If you decide to participate in this study, you may face the risk that a release of confidential information can occur. Pseudonyms will be used for people and their affiliations, and locations will be described and not named specifically when reporting findings related to the focus group interview data. The actual audio/videotaped data and transcriptions will be stored on ODU password-protected storage and only accessible by the investigators listed above who have been and continue to be trained about the proper handling of human subjects' data.

BENEFITS: The main benefit to you for participating in this professional development is gaining the knowledge and skills to facilitate the implementation of culturally responsive mathematics teaching *through* problem-solving. Attending the professional development in its entirety will entitle you to also receive professional development hours for your participation.

COSTS AND PAYMENTS
The researchers want your decision about participating in this study to be voluntary. The researchers are unable to give you any payment for participating in this survey.

NEW INFORMATION
If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY
The researchers will take reasonable steps to keep private information confidential. The researcher will remove identifiers from all identifiable private information collected. The audio/videotaped and transcribed data will be stored on ODU password-protected storage and only accessible by the investigators listed above who have been and continue to be trained about the proper handling of human subjects' data. The results of this study may be used in reports, presentations, and publications; but the researcher will not identify you.

WITHDRAWAL PRIVILEGE
It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the professional development session at any time. Your decision will not affect your relationship with Old Dominion University or otherwise cause a loss of benefits to which you might otherwise be entitled.

COMPENSATION FOR ILLNESS AND INJURY
If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of harm or injury rising from this study, neither Old Dominion University nor the researchers can give you any money, insurance coverage, free medical care, or any other compensation for such injury. If you suffer injury because of participation in this research project, you may contact the Responsible Principal Investigator, Dr. Melva Grant at 757-683-5725, Dr. John Baaki the current IRB chair at 757-683-5491 at Old Dominion University, or the Old Dominion University Office of Research at 757-683-3460 who will be glad to review the matter with you.

VOLUNTARY CONSENT
By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions about the study, contact the Responsible Principal Investigator, Dr. Melva Grant at 757-683-5725. If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. John Baaki, the current IRB chair, at 757-683-5491, or the Old Dominion University Office of Research, at 757-683-3460.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Subject's Printed Name & Signature	**Date**

INVESTIGATOR'S STATEMENT
I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during this study. I have witnessed the above signature(s) on this consent form.

Investigator's Printed Name & Signature	**Date**

APPENDIX H

Rich Math Task – Professional Development

Summer Passes

Michael, Susie, and Karl plan to purchase summer passes to a local amusement park. They decide to work summer jobs to earn the money for the summer passes.

- Michael will babysit his little brother every day. He will earn $10 a day for babysitting.

- Susie's sister has a summer lawn care business. Susie will help her sister pull weeds out of the flower beds every day. Her sister will pay her $50 upfront and then a dollar each day.

- Karl had already saved $35 for his summer pass. His mom agrees to give him one dollar for every day that he does his chores. Karl does his chores every day.

If a summer pass to the amusement park costs $86, who will be the first one to have enough money to buy the pass? How long will it be before they can all go together? Explain your reasoning and give evidence of your position.

APPENDIX I

Informed Consent – Lesson study

INFORMED CONSENT DOCUMENT
OLD DOMINION UNIVERSITY

PROJECT TITLE: Exploring Math Teachers' Culturally Responsive Mathematics Teaching *through* Problem-Solving

INTRODUCTION
The purposes of this form are to give you information that may affect your decision whether to say YES or NO to participate in this Lesson Study on Culturally Responsive Mathematics Teaching *through* Problem Solving, and to record the consent of those who say YES.

RESEARCHERS
Melva R. Grant, Ph.D., Responsible Project Principal Investigator, Professor of Mathematics Education, Darden College of Education & Professional Studies, Department of Teaching & Learning
Tisha Jones, Student Investigator, Curriculum and Instruction Doctoral Student, Darden College of Education & Professional Studies, Department of Teaching & Learning

DESCRIPTION OF RESEARCH STUDY
You are invited to participate in a lesson study about culturally responsive mathematics teaching *through* problem-solving, an equity-oriented mathematics teaching approach. The continued inequitable practices present in K-12 mathematics teaching in the United States suggest that more research is needed to determine what it means to be a culturally responsive mathematics teacher and how to integrate it with teaching *through* problem-solving. Despite a great deal of research in mathematics education about culturally responsive pedagogy and problem-solving, researchers know little about the potential for culturally responsive mathematics teaching *through* problem-solving and its influence on students' engagement, dispositions, and mathematics learning. The purpose of this lesson study is to examine the effects of lesson study to improve the implementation of culturally responsive mathematics teaching *through* problem-solving in secondary mathematics.

Participants include secondary mathematics teachers and special education teacher collaborators who are employed by Norfolk Public Schools. If you decide to participate, this lesson study will last approximately 4 weeks. Norfolk Public Schools employees will receive professional development hours for your participation. Your participation in this lesson study is voluntary.

RISKS AND BENEFITS
RISKS: The researchers are trying to capture your thoughts and perspectives about culturally responsive mathematics teaching through problem-solving through the lesson study process. Your discussions and responses during the lesson study sessions and teaching will be recorded by audio/videotape and kept confidential. If you decide to participate in this lesson study, you may face a risk that a release of confidential information can occur. Pseudonyms will be used for people and their affiliations, and locations will be described and not named specifically when reporting findings related to the focus group interview data. The actual audio/videotaped data and transcriptions will be stored on ODU password protected storage and only accessible by the investigators listed above who have been and continue to be trained about the proper handling of human subjects' data.

BENEFITS: The main benefit to you for participating in this lesson is gaining the knowledge and skills to facilitate the implementation of culturally responsive mathematics teaching *through* problem-solving. Participating in the lesson study in its entirety will entitle you to also receive professional development hours for your participation.

COSTS AND PAYMENTS
The researchers want your decision about participating in this study to be voluntary. The researchers are unable to give you any payment for participating in this survey.

NEW INFORMATION
If the researchers find new information during this study that would reasonably change your decision about participating, then they will give it to you.

CONFIDENTIALITY
The researchers will take reasonable steps to keep private information confidential. The researcher will remove identifiers from all identifiable private information collected. The audio/videotaped and transcribed data will be stored on ODU password protected storage and only accessible by the investigators listed above who have been and continue to be trained about the proper handling of human subjects' data. The results of this study may be used in reports, presentations, and publications; but the researcher will not identify you.

WITHDRAWAL PRIVILEGE
It is OK for you to say NO. Even if you say YES now, you are free to say NO later, and walk away or withdraw from the professional development session at any time. Your decision will not affect your relationship with Old Dominion University, or otherwise cause a loss of benefits to which you might otherwise be entitled.

COMPENSATION FOR ILLNESS AND INJURY
If you say YES, then your consent in this document does not waive any of your legal rights. However, in the event of harm or injury rising from this study, neither Old Dominion University nor the researchers can give you any money, insurance coverage, free medical care, or any other compensation for such injury. If you suffer injury because of participation in this research project, you may contact the Responsible Principal Investigator, Dr. Melva Grant at 757-683-5725, Dr. John Baaki the current IRB chair at 757-683-5491 at Old Dominion University, or the Old Dominion University Office of Research at 757-683-3460 who will be glad to review the matter with you.

VOLUNTARY CONSENT
By signing this form, you are saying several things. You are saying that you have read this form or have had it read to you, that you are satisfied that you understand this form, the research study, and its risks and benefits. The researchers should have answered any questions you may have had about the research. If you have any questions about the study, contact the Responsible Principal Investigator, Dr. Melva Grant at 757-683-5725. If at any time you feel pressured to participate, or if you have any questions about your rights or this form, then you should call Dr. John Baaki, the current IRB chair, at 757-683-5491, or the Old Dominion University Office of Research, at 757-683-3460.

And importantly, by signing below, you are telling the researcher YES, that you agree to participate in this study. The researcher should give you a copy of this form for your records.

Subject's Printed Name & Signature	**Date**

INVESTIGATOR'S STATEMENT
I certify that I have explained to this subject the nature and purpose of this research, including benefits, risks, costs, and any experimental procedures. I have described the rights and protections afforded to human subjects and have done nothing to pressure, coerce, or falsely entice this subject into participating. I am aware of my obligations under state and federal laws and promise compliance. I have answered the subject's questions and have encouraged him/her to ask additional questions at any time during this study. I have witnessed the above signature(s) on this consent form.

Tisha Jones *Tisha Jones* **Investigator's Printed Name & Signature**	**Date - 4/6/23**

APPENDIX J

Rich Math Task – Research Lesson

Summer Passes

Dontae, Amber, and Roberto plan to purchase summer passes to Busch Gardens. They decide to work after-school jobs to earn the money for the summer passes.

Dontae will babysit his little brother every day. He will earn $10 a day for babysitting.

Amber's sister has a summer lawn care business. Amber will help her sister pull weeds out of the flower beds every day. Her sister will pay her $50 upfront and then a dollar each day.

Roberto has already saved $35 for his summer pass. His mom agrees to give him one dollar for every day that he does his chores. Roberto does his chores every day.

If a summer pass to Busch Gardens costs $86, who will be the first one to have enough money to buy the pass? How long will it be before they can all go together? Explain your reasoning and give evidence of your position.

APPENDIX K

Reflection Journal Question

Introduction

B1. When you hear the phrase "culturally responsive equitable problem-solving pedagogy", what do you think of?

B2. How would you define "culturally responsive equitable problem-solving pedagogy"?

B3. What do you think teachers should be doing during a lesson that implements "culturally responsive equitable problem-solving pedagogy"?

B4. What do you think students should be doing during a lesson that implements "culturally responsive equitable problem-solving pedagogy"?

After first observation

R1. What were the strengths of the research lesson?

R2. What were some opportunities for the next research lesson?

R3. Suggestions for additional teaching moves.

R4. Suggestions for greater student engagement.

After second observation

R5. What were the strengths of the research lesson?

R6. What were some opportunities for the next research lesson?

R7. Suggestions for additional teaching moves.

R8. Suggestions for greater student engagement.

After third observation

R9. What were the strengths of the research lesson?

R10. What were some opportunities for the next research lesson?

R11. Suggestions for additional teaching moves.

R12. Suggestions for greater student engagement.

After the Lesson Study Discussion Guiding Questions:

R13. What are your views about the teaching and learning of mathematics?

Sub question 1: In other words, how can students best learn mathematics?

Sub question 2: How can teachers best teach mathematics?

R14. Regarding your view of mathematics teaching and learning, what changes, if any, have you made through participating in this lesson study?

Sub question 1: Why did you make these changes?

R15. What are your beliefs about culturally responsive mathematics teaching through problem solving with equitable practices?

Sub question 1: Have those beliefs changed while participating in the lesson study?

R16. What part, if any, was most helpful in understanding culturally responsive mathematics teaching through problem solving with equitable practices? For example, participating in the lesson study itself, or specifically, the discussions, reflections, implementing the lessons, observing the lessons, etc.

R17. If you were given an opportunity to share experiences with lesson study to colleagues, what would you say?

R18. If you were given an opportunity to share experiences with culturally responsive mathematics teaching through problem solving with equitable practices, what would you say?

R19. What are the main things you are going to take away from this lesson study experience?

Sub question 1: How will it impact your teaching?

Conclusion

A1. Now that you've had time to read, discuss, and experience "culturally responsive mathematics teaching through problem solving with equitable teaching practices", is there anything you would like to add or change about what you think of when you hear it?

A2. After experiencing "culturally responsive mathematics teaching through problem solving with equitable teaching practices", How would you define it now?

A3. After experiencing "culturally responsive mathematics teaching through problem solving with equitable teaching practices", what do you think teachers should be doing during a lesson?

A4. After experiencing "culturally responsive mathematics teaching through problem solving with equitable teaching practices", what do you think students should be doing during a lesson?

A5. Were there any teaching practices you found difficult to implement? List them and explain why they were difficult.

VITA

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Darden College of Education
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Norfolk, VA 23529

Tisha N. Jones is the senior coordinator of secondary mathematics in a public school district in Norfolk, Virginia. She was a former mathematics specialist in Norfolk and Portsmouth, Virginia and a former secondary mathematics teacher in Greenville, North Carolina. She is a doctoral candidate at Old Dominion University and her research interests include culturally responsive mathematics teaching and mathematical problem solving.

Professional Experience

Senior Coordinator of Secondary Mathematics, July 2021
Norfolk Public Schools, Norfolk, VA

District Mathematics Program Specialist, August 2016
Portsmouth Public Schools, Portsmouth, VA

Mathematics Teacher Specialist, August 2013
Norfolk Public Schools, Norfolk, VA

Secondary Mathematics Teacher, September 1994
Pitt County Schools, Greenville, North Carolina

Education

Education Specialist, Educational Leadership, August 2019
Old Dominion University, Norfolk, VA
Administrative Certification: K-12 Supervision and Leadership

Master of Arts in Education, Mathematics Education, August 2006
East Carolina University, Greenville, NC
Teacher Certification: Secondary Mathematics

Bachelor of Science, Biology and Mathematics, May 1994