EXAMINING OPPORTUNITIES TO LEARN AND ENACT AMBITIOUS INSTRUCTION, CULTURALLY RESPONSIVE TEACHING, AND CULTURALLY RELEVANT PEDAGOGY IN MATHEMATICS EDUCATION

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APPROVAL OF THE DISSERTATION

This dissertation, Examining Opportunities to Learn and Enact Ambitious Instruction, Culturally Responsive Teaching, and Culturally Relevant Pedagogy in Mathematics Education, has been approved by the Graduate Faculty of the Curry School of Education & Human Development in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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DEDICATION

To all of the children who feel life's adversity but who find courage in chasing after their dreams even when they feel true otherness. We live in the fear of not belonging and we feel bound by the social structures, institutions, and people who tell us who we are supposed to be.
Do not let them define you.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Examining Opportunities to Learn and Enact Ambitious Instruction, Culturally Responsive Teaching, and Culturally Relevant Pedagogy in Mathematics Education

Overview and Conceptual Links

In mathematics education, effective teaching practices or instructional strategies are those which align with standards-based teaching (e.g., NCTM, 2000). Furthermore, standards-based teaching is viewed as foundational to the enactment of ambitious mathematics instruction (Lampert et al., 2010). However, ambitious pedagogies must also be responsive (Lampert et al., 2010) to learners and equitable, especially for historically marginalized youth (Gutierrez, 2013). Therefore, even though the frameworks for culturally relevant pedagogy (CRP) (Ladson-Billings, 1994) and culturally responsive teaching (CRT) (Gay, 2000) have informed the field for some time, scholars (e.g., Bonner, 2014) continue to discuss how to operationalize such pedagogy in mathematics education to make teaching practices more equitable and empowering for learners. Thus, conversations arise around the relationship between CRP and/or CRT and the development and enactment of ambitious mathematics instruction. The three manuscripts for this dissertation examine learning opportunities and/or the enactment of such pedagogies to continue to inform our understanding how to operationalize such teaching practices in content-specific ways.

Standards-Based Mathematics Teaching Practices

Standards-based refers to teaching practices that provide learners with opportunities to engage in mathematical practices or behaviors (e.g., math discourse, representation) as outlined in the National Council of Teachers of Mathematics process standards (NCTM, 2000; Walkowiak, Berry, Pinter, & Jacobson, 2018). Such teaching practices also capture more recent standards (e.g., mathematical modeling and argumentation) in the United States released by the

National Governors Association Center for Best Practices and Council of Chief State School Officers (2010) (Walkowiak et al., 2018). All of these standards focus on teaching practices that support the development of conceptual understanding. Conceptual understanding has been defined as, "an integrated and functional grasp of mathematical ideas" (NRC, 2001, p.18). Smith et al. (2017) claim that to meet the demands of such standards, teachers have to engage in ambitious teaching practices.

Ambitious Mathematics Instruction

The construct of ambitious instruction is well supported in the literature on teaching (Franke, Kazemi, & Battey, 2007; Grossman, Cohen, Ronfeldt, & Brown, 2014; Lampert, Boerst, & Graziani, 2011; Thompson, Windschitl, & Braaten, 2013). Across the manuscripts in this dissertation, I define ambitious instruction as a set of teaching practices that foster students' deep conceptual understanding of standards-based teaching practices (Newman & Associates, 1996). Thus, we can discuss how the vision for mathematics teaching and learning in NCTM (2000; 2014) documents outline ambitious instruction (Lampert et al., 2010). Smith et al. (2017) state that the eight teaching practices outlined by NCTM (2014) provide guidance for enacting ambitious pedagogies, but further claim that "ambitious mathematics teaching must be equitable" (pp. 5).

Equitable Teaching and Learning

While Driscoll, Nikula, and DePiper (2016) confront the challenges of defining "equity" they acknowledge that equitable teaching practices fairly address the needs of learners and provide different access points for students to learn mathematics and approach mathematical tasks. This means that equitable teaching begins with teachers believing in learners' potential to engage with challenging mathematics (Driscoll, Nikula, & DePiper, 2016). While NCTM (2014)

addresses essential elements of ensuring access and equity in school mathematics programs, teacher resources (e.g., Smith et al., 2017) also outline equity-based teaching practices to support mathematics learning. While such sources outline the benefits of equitable practices for all learners, researchers continue to discuss the learning opportunities afforded to historically marginalized youth.

Culturally responsive teaching and culturally relevant pedagogy. Research suggests that the achievement of historically marginalized youth is likely to increase when learners have positive mathematical identities (e.g., Borman & Overman, 2004) and cultural identities (e.g., Moll, Amanti, Neff, & González, 1992). Gay (2010) states, "Culturally responsive teaching is a means for unleashing the higher learning potentials of ethnically diverse students by simultaneously cultivating their academic and psychosocial abilities" (p. 21). The theoretical frameworks for CRT (Gay, 2000) and CRP (Ladson-Billings, 1994) have continued to informed our conceptualization of providing equitable, empowering, and responsive pedagogy for historically marginalized youth. Shadiow (2006) stated, "There is no escaping the fact that education is a sociocultural process. Hence, a critical examination of the role of culture in human life is indispensable to the understanding and control of educative processes" (p. 6). While teachers and researchers see the importance of incorporating CRT and CRP, there is uncertainty as to what this looks like in practice in mathematics classrooms.

Elementary Mathematics Education

Elementary school experiences set the stage for students regarding what it means to be a participant within a classroom community of learners. This critical time is also when students start to form beliefs about what it means to do mathematics and their mathematical identities (Aguirre, et al., 2013). Thus, the importance of forming growth mindsets or mathematical

mindsets (Boaler, 2016) within mathematics teaching and learning often becomes a central focus in elementary school education. It is also critical to acknowledge that for most early elementary students, attending school heightens their awareness of cultural differences, especially those between home and school. Therefore, it is pivotal that teachers foster the development of students' cultural identities (e.g., Moll, Amanti, Neff, & González, 1992).

Dissertation Overview

The focus of this dissertation is on ambitious pedagogies in mathematics education teaching and learning. The goal across the three manuscripts was to focus upon how pre-service (teacher candidates) and in-service teachers have opportunities to learn and enact ambitious mathematics instruction including that which supports CRP and CRT. The first paper uses qualitative metasynthesis as the methodological framing to synthesize qualitative research to understand how researchers interpret mathematics teaching practices that support CRT and CRP in pre-kindergarten through 12th grade. The second manuscript is based upon a multi-case study that explores teacher candidates' opportunities to learn ambitious pedagogies based upon their methods instructors' beliefs about effective teaching practices in elementary mathematics. The third manuscript is based upon a different multi-case study that explores the mathematics teaching practices of three elementary teachers who have been certified in CRT by professional development opportunities in their district. Holistically, these studies offer insight into the instructional strategies used in elementary mathematics education. The table below demonstrates the focus of each manuscript.

Table 1: Three Manuscript Overview

Manuscript	Focus
1. Qualitative Metasynthesis	Researchers' interpretation of teachers' enactment of CRT and CRP in mathematics preK-12
2. Teacher Preparation in Elementary Mathematics	Teacher candidates' opportunities to learn ambitious pedagogies in elementary mathematics
3. District Certified CRT Elementary Mathematics Teachers	Teachers' learning opportunities of CRT in district certification and their enactment in elementary mathematics

Manuscript 1: Qualitative Metasynthesis

There has been a large body of research focusing upon CRT and CRP across all content areas. Mathematics education has benefited from teaching and research using the tenets of CRP and CRT. Much of the research using the tenets of CRP and CRT in mathematics education employs qualitative methodological approaches. However, this work has yet to be synthesized and interpreted using methodologies for qualitative metasynthesis. A qualitative metasynthesis is differentiated from a literature review due to the process of selecting, synthesizing, analyzing, and interpreting the findings across studies to integrate a large body of literature (Thorne et al., 2004).

This research uses a qualitative metasynthesis (e.g., Thunder and Berry, 2016) as a methodological approach for mathematics education research. This work synthesizes and interprets qualitative research published between 1994 and February 2016. Initial searches produced 1,224 articles, but through a process of appraisals, 12 articles were synthesized to understand how researcher interpret mathematics teaching practices that support CRT and CRP in pre-kindergarten through 12th grade in the United States. The five findings focus on teaching practices including: caring, context, cultural competency, high expectations, and mathematics

instruction. The finding on *mathematics instruction* outlines how CRP/CRT practices across these works align with standards-based mathematics practices. Implications of this work suggests that more work is needed in the field to understand support structures that facilitate teachers in their enactment of CRP/CRT; the role of critical consciousness in mathematics education instruction; and, the relationship between teachers' mathematics knowledge for teaching and their enactment of CRP/CRT. This manuscript has been published in the *Journal of Mathematics Education at Teachers College* (Thomas & Berry, 2019).

Manuscript 2: Teacher Preparation in Elementary Mathematics

Recent literature (e.g., Lampert et al., 2013) unpacks ambitious pedagogies in mathematics teacher education. Yet, as documented by Clift and Brady (2005), there is still much to learn about the various instructional strategies employed by mathematics methods instructors as well as the learning opportunities afforded to teacher candidates (TCs) (Cavanna, Drake, & Pak, 2017). In mathematics education literature (e.g., Lampert et al., 2010), ambitious instruction and standards-based teaching practices are often used together or in place of one another. Thus, research (e.g., Walkowiak, et al., 2018) documents how observation measures of standards-based teaching practices can be utilized to observe for ambitious mathematics instruction. Therefore, such measures can be employed qualitatively to examine the ambitious practices of elementary mathematics methods instructors.

Provided that the instructors' teaching practices translate into observable actions that provide learners with opportunities to engage in mathematical practices or behaviors, we can further examine TCs having opportunities to learn (OTL) ambitious instruction. While there is variability in definitions for OTL, Schmidt and colleagues' framework for OTL, defines it as, "the content to which future teachers are exposed as a part of their teacher preparation programs"

(Schmidt, Cogan, & Houang, 2011, p. 140). This framework differentiates the content that TCs have the OTL within their mathematics teacher preparation coursework based upon four categories: mathematics, mathematics pedagogy, general pedagogy, and practical experience (Schmidt, Blömeke, et al., 2011; Youngs & Qian, 2013). Further, I take the position that "Teachers' beliefs influence the decisions that they make about the manner in which they teach mathematics" (NCTM, 2014, p. 10).

This multi-case study examines how three elementary mathematics methods instructors in the same teacher education program provide their TCs with OTL ambitious pedagogies. Specifically, this study focuses upon the learning opportunities for TCs that stem from the instructional strategies used by their methods instructors. The findings suggest that the instructors' beliefs about effective mathematics teaching practices influence the content that teacher candidates have the opportunity to learn and the nature of the TCs' OTL. Through analytic induction, three assertions were developed to understand and explicate: similarities in OTL, differences in OTL, and perceptions about the purpose of the methods courses across the three cases. The findings contribute to our understanding of TCs' OTL ambitious instructional strategies within one teacher education program. This manuscript has been submitted to the *Journal of Mathematics Teacher Education* for a second-round of revisions.

Manuscript 3: District Certified CRT Elementary Mathematics Teachers

Scholars (e.g., Hammond, 2015) continue to discuss the challenges of how to operationalize CRT in practice. Mathematics education in particular has produced limited research examining the teaching practices of culturally responsive teachers in pre-kindergarten through 12th grade (preK-12) (Thomas & Berry, 2019). Bonner (2014) offers three reasons for why this might be the case, including: 1) the majority of the works are specific to one population

such as African American learners (e.g., Ladson-Billings, 1994); 2) there is a broad focus on content and practice, making it non-mathematics-specific (e.g., Gay, 2010); 3) and, the works remain largely theoretical (e.g., Greer et al., 2009).

This multi-case study builds upon the first manuscript, and attempts to link research and practice with CRT. The study examines how three elementary teachers, all certified by their school district in CRT through professional development opportunities, implement mathematics teaching practices that support CRT. Furthermore, this study examines the CRT certification process in the focal district and the structures that support teachers in their enactment of CRT. Data were collected via interviews, questionnaires, observations, teacher journals, and other reportable data. The teachers' CRT practices in mathematics fell into four large quadrants aligning with the work of Hammond's (2015) Ready for Rigor framework. The findings expand upon the literature and provide us with a more informed understanding of what CRT looks like in elementary mathematics classrooms with teachers who have been certified in CRT from a district developed and applied certification model.

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Manuscript One

A Qualitative Metasynthesis of Culturally Relevant Pedagogy & Culturally Responsive Teaching: Unpacking Mathematics Teaching Practices

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Abstract

This article uses Culturally Relevant Pedagogy (CRP) and Culturally Responsive Teaching (CRT) as the theoretical frameworks and qualitative metasynthesis as the methodological framework to synthesize qualitative research published between 1994 and February of 2016. Initial searches produced 1,224 articles, but through a process of appraisals, 12 articles were synthesized to understand how researchers interpret mathematics teaching practices that support CRP and CRT in pre-kindergarten through 12th grade. There were five findings focused on teacher practices, classroom interactions, and student experiences with CRP and CRT within mathematics education, including: caring, context, cultural competency, high expectations, and mathematics instruction.

Mathematics education has benefited from teaching and research using the tenets of Culturally Relevant Pedagogy (CRP) and Culturally Responsive Teaching (CRT), yet there is little understanding about the impact of these tenets on mathematics teaching practices. Much of the research focused on CRP and CRT employs qualitative methodologies to examine the intersections of mathematics teaching with CRP and CRT frameworks. This research has yet to be synthesized, analyzed, and interpreted to provide the field of mathematics education with deeper insights and broader perspectives of teaching practices within the frameworks of CRP and CRT as evidence-based practices. CRP and CRT are frameworks that respond to traditional mathematics teaching practices by empowering learners to see the multiple purposes for learning mathematics, helping learners appreciate why mathematics is important in their lives, and allowing learners to believe they can succeed in mathematics.

Within CRP and CRT, mathematics is experienced as problem-solving and ways to critique and understand the world (Gutstein, 2009). The ways in which students experience mathematics significantly impact the ways in which they identify themselves as doers of mathematics. CRP and CRT are frameworks that recognize that learners' identities in mathematics are highly contextualized and mediated by environments; consequently, these frameworks consider the contexts of learners' lives, experiences, and backgrounds. Mathematics teaching varies across context and is challenging to generalize because teaching is dependent on contextual, cultural, and social factors. While it is challenging to generalize across varying context, we can learn a lot from unpacking research focused on mathematics teaching that considers contextual, cultural, and community factors. Significant research centralizes the experiences and contexts of marginalized[1] learners. Mukhopadhyay, Powell, and Frankenstein's

[1] When we use the term marginalized learners, we are not ascribing a sweeping set of attributes to the collectives of Black, Latinx, Indigenous, and poor peoples; we recognize that collapsing these groups into one group

(2009) work acknowledged that mathematics teaching must consider the practices of all peoples. Lampert (2001) found that mathematics teaching should include building relationships with all students so that diverse ideas can be examined and understood. Building relationships and considering the practices of all peoples are described by many researchers as building on students' "funds of knowledge." Funds of knowledge assume a broad range of elements in peoples' lives including cultural experiences, artifacts, values, feelings, language and identity (Moll & Gonzalez, 2004). Bonner (2014) described three teachers using identity, language, and culture in their teaching of mathematics. Civil and Khan (2001) unpacked teaching practices to connect students' families' experiences with teaching counting, measurement, perimeter, and area. The common thread through these works challenges the notion that mathematics teaching is culturally neutral and that there are universal truths regarding teaching practices. These studies situate mathematics teaching as eliciting shared frames of references to make meaningful connections between teaching and the cultures, lives, and experiences of learners.

Frameworks

Theoretical Frameworks: CRP & CRT

This research used Gloria Ladson-Billings' (1994) and Geneva Gay's (2000) frameworks to unpack and understand mathematics teaching practices embedded in classrooms as sites for social change and social justice. These frameworks connect cultural framing to academic skills

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does not acknowledge the intersectionality within these collectives. Martin (2015) argued that one dominant discourse in mathematics education research focuses on a fixed set of cultural and cognitive explanations for negative outcomes, including cultural differences or deficits, limited mathematical knowledge and problem-solving skills, family background and socioeconomic status, and oppositional orientations to schooling. Although there are differences among the collectives, they share legacies of being positioned as deficient in research and they also share values and beliefs that prioritize community and family, a respect for spirituality, and interconnectedness with the natural world (Barnhardt, 2001; Berry, 2008; Gutiérrez, 2013).

and concepts, build cultural competence through teaching, and use teaching as a way to critique power discourses and representations.

Gloria Ladson-Billings (1994) defined CRP as pedagogy "that empowers students intellectually, socially, emotionally, and politically using cultural referents to impart knowledge, skills, and attitudes" (pp. 17-18). Teachers must develop both sociocultural consciousness and a holistic view of caring before they can truly engage in CRP (Morrison, Robbins, & Rose, 2008; Ladson-Billings, 1995; Ladson-Billings, 2006). The three tenets of CRP are:

- *Academic achievement* refers to helping learners realize that they have the potential to attain high levels of achievement. Teaching practices associated with this tenet include setting high expectations for learners, providing support mechanisms, assisting learners in determining long-term goals, and helping learners advocate for their own well-being.
- *Cultural competence* refers to ways in which teachers keep the cultures of their children in the forefront of their minds and honor and respect the learners' home culture within daily interactions and instruction (Ladson-Billings, 1994). Teaching practices related to cultural competence include providing supports for learners in navigating dominant cultural capital to attain academic achievement while simultaneously helping learners to honor their own cultural identity.
- *Sociopolitical consciousness* is developed within historically marginalized youth when teachers help their students to "understand the world as it is and equip them to change it for the better" (Ladson-Billings, 1994, p. 139). Teaching practices linked to sociopolitical consciousness create structures to help learners recognize, understand, and critique current and social inequalities.

Geneva Gay (2010) defined CRT as "…using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them" (p. 31). CRT is the behavioral expression of knowledge, beliefs, and values that recognizes the importance of racial and cultural diversity in learning. Gay (2010) outlines six dimensions of CRT:

- CRT *validates* children's cultural heritages to "build bridges of meaningfulness between home and school experiences as well as between academic extractions and lived sociocultural realities" (Gay, 2010, p. 31). Teaching practices validate learners' cultural heritage by incorporating instructional strategies and multicultural resources and curricula.
- Culturally responsive teachers develop intellectual, social, emotional, and political *comprehensive* learning opportunities to teach the whole child (Gay, 2010). Teaching practices related to comprehensive learning opportunities create structures where learning is communal and supports helping learners maintain their cultural identities as members of their communities.
- CRT is *multidimensional* because it "encompasses curriculum content, learning context, classroom climate, student-teacher relationships, instructional techniques, classroom management, and performance assessments" (Gay, 2010, p. 33). Teaching practices have to engage extensively with cultural knowledge, experiences, contributions, and perspectives.
- CRT leads to *self-determination* and *empowerment*. Self-determination and empowerment help learners believe that achievement is within their reach. Teaching

practices linked to self-determination and empowerment support learners, holding them to high expectations both academically and socially.

- CRT is *transformative* because it defies traditional educational practices and cultural hegemony and develops social consciousness, intellectual critique, and political and personal efficacy. Teaching practices that are transformative create structures to help learners combat prejudices, racism, and other forms of oppression and exploitation.
- CRT is *emancipatory* and *liberating* because it "lifts the veil of presumed absolute authority from conceptions of scholarly truth typically taught in schools" (Gay, 2010, p. 38). Teaching practices associated with being emancipatory and liberating challenge the notion of universal truths and the belief that knowledge is permanent.

Aronson and Laughter (2016) collectively examined the work of both Ladson-Billings and Gay and defined culturally relevant education (CRE). They identified four markers of CRE: a) academic skills and concepts, b) critical reflection, c) cultural competence, and d) critique discourse of power. Aronson and Laughter (2016) stated that their findings were supported by a sufficient body of research. We examined their study critically because their literature search produced "more than 286 results" across all subject areas (p. 16). This qualitative metasynthesis produced 1,224 articles just in the discipline of mathematics education. In the end, Aronson and Laughter (2016) synthesized eight studies in mathematics from 1995 to 2013 while we synthesized 12 studies focused on teaching practices that support CRP and CRT in pre-kindergarten (Pre-K) through 12th grade.

Methodological Framework: Qualitative Metasynthesis

Qualitative metasynthesis is a methodological process to integrate a large body of related research literature. While reviews of literature and meta-analyses synthesize research, a

qualitative metasynthesis is distinct because of its methodological framing. A review of literature summarizes the strengths and weaknesses of previous research for the purpose of establishing previous findings and claims that are relevant to the current focus of inquiry. During a review of literature, researchers locate their original inquiry within the context of what has previously been studied so as to convince the reader that this additional study is justifiable and that the results of the study will have relevance to some aspect of advancing the body of literature (Thorne, Jensen, Kearney, Noblit, & Sandelowski, 2004). A qualitative metasynthesis is not a review of literature; it is an analysis and interpretation of the findings from selected studies. Researchers conducting qualitative metasynthesis use a deliberate process of selecting studies with the emphasis on synthesizing, analyzing, and interpreting findings across the selected studies. The process of selecting, synthesizing, analyzing, and interpreting findings across studies differentiates qualitative metasynthesis from a review of literature (Thorne et al., 2004).

Synthesizing a collective body of qualitative research in education provides us with deeper insights and makes for a greater contribution to understanding how a collective body of research contributes to our understanding of a particular topic within the field. In this milieu of evidence-based support, qualitative metasynthesis broaden the perspectives on evidence-based research, practice, and policy by expanding how knowledge can be generated and used. In an effort to connect research to practice, qualitative metasynthesis move from knowledge generation to knowledge application by helping researchers make sense of a collective body of research for practice (Erwin, Brotherson, & Summers, 2011; Berry & Thunder, 2012).

Six discrete steps were followed for this qualitative metasynthesis: 1) identify a specific research metaquestion; 2) conduct a comprehensive search; 3) select initial relevant studies; 4)

appraise the quality of initially selected studies; 5) synthesize findings of selected studies; and 6) present findings across the studies.

The formulation of a research question for a qualitative metasynthesis is similar to the formulation of a research question for a qualitative research study. A qualitative research question encapsulates the purpose of a qualitative study and identifies the central phenomenon to be studied. A qualitative metasynthesis research question is referred to as a metaquestion—a question that has already been studied qualitatively. The research metaquestion for this study is: How do researchers interpret mathematics teaching practices that support Culturally Relevant Pedagogy (CRP) and Culturally Responsive Teaching (CRT) in pre-kindergarten through 12th grade?

The purpose of this study was to synthesize papers that demonstrated CRP and/or CRT in mathematics education, which has yet to be done within the methodological framework of a qualitative metasynthesis. For the purpose of this work, we will specifically look at our findings as they relate to unpacking mathematics teaching practices that support CRP and CRT in pre-kindergarten through 12th grade.

Design/Methods

Researcher Positionality

We take the position that researchers conducting qualitative research should acknowledge their influence in the study by describing their experiences and assumptions with which the researchers enter the research (Foote & Bartell, 2011). Both our experiences as mathematics teachers and the equity lens that we bring to this study shape the ways we position teaching mathematics. As former secondary mathematics teachers, we reflect upon ways to improve teaching practices to make mathematics more accessible, equitable, and empowering for all

learners, especially those who have been historically marginalized. We do not discount the fact that race, gender, social class, and political views affected the research process. Acknowledging the roles that race, gender, and power play in the research process, the co-authors identify themselves as a White woman and a Black man; and as doctoral student and doctoral advisor.

Data Collection

Published peer reviewed research papers between 1994 and 2016 using qualitative methodologies focused on CRP and CRT were sought for this qualitative metasynthesis. Prior to conducting database searches, inclusion and exclusion criteria were developed based on four parameters: topical, population, methodological, and temporal (as seen in Table 1). All papers used CRP and/or CRT as frameworks (topical) and the research focused on mathematics teaching and learning in Pre-K-12 contexts in the United States (population). Qualitative research was the methodological framework for all papers; however, mixed methods research studies were included if the qualitative findings were distinguishable.

Table 1: Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Topical Culturally Responsive Teaching/Culturally Relevant Pedagogy	Not Culturally Responsive Teaching/Culturally Relevant Pedagogy
Population • Pre-K-12 students and educators • Preservice Teachers • Only within the United States • Only Mathematics: with strong mathematics focus • Teachers/Students: with strong focus on teaching and learning practices	• Not within the United states • Doesn't focus solely on Mathematics
Methodological • Qualitative Research • Mixed Methods if it clearly distinguishes qualitative data from quantitative	• Quantitative Research • Qualitative data with no student/teacher interactions • Mixed Methods that doesn't distinguish qualitative data from quantitative
Temporal 1994 – February 2016	
Additional Inclusion Criteria Peer reviewed and refereed journal articles	**Additional Exclusion Criteria** • Newspaper Articles/Journalistic • Dissertations, non-peer reviewed articles, and book chapters

Subject term searches were conducted using EBSCO to simultaneously search five databases for peer reviewed journal articles. The five databases included: Academic Search Complete, Education Full Text (H.W. Wilson), Education Research Complete, ERIC, and Psychology and Behavioral Sciences Collection. The search terms were *culturally responsive teaching* or *culturally relevant pedagogy*, and math*. Math* was used to encompass all articles which may have used math and/or mathematics as keywords. Additional criteria were selected to generate articles which were peer reviewed and fell within the source type as academic journals and journals within the time frame specified. Book reviews, reports, chapters, and dissertations

are examples of items that were excluded. Figure 1 shows the flowchart of inclusion and appraisal to determine articles for the qualitative metasynthesis.

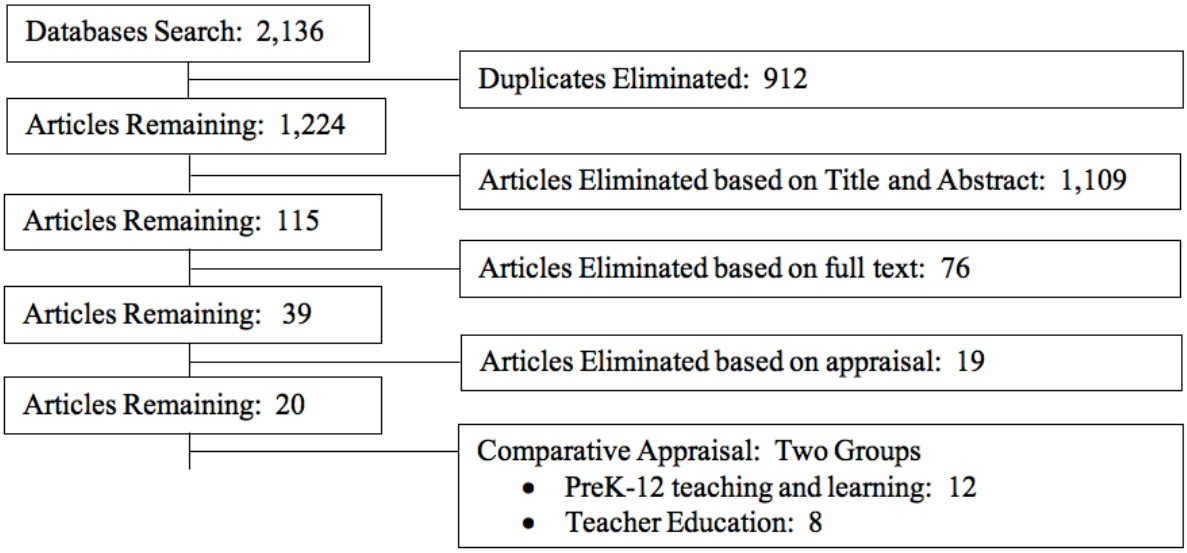

Figure 1: Flowchart of Inclusion and Appraisal

The initial EBSCO search produced 1,224 articles. Following our initial search, we worked through a validation process by looking at the titles, abstracts, subject terms, and full text for published peer reviewed journal articles. This process left further 39 articles fitting the inclusion criteria. We then performed individual appraisals for each article, appraising the quality of the research methodologies using the rubric published by Thunder and Berry (2016) as seen in Figure 2. Following their appraisal process, 20 articles were identified. Further, we did a comparative appraisal, dividing the articles into two groups: 1) Pre-K-12 teaching and learning; and 2) teacher education. This qualitative metasynthesis treats the findings from 12 articles focused on Pre-K-12 teaching and learning as informants (the 12 articles are marked with an * in the reference section). Dedoose, a data analysis software, was used to support data analysis and initial codes were developed and defined. Six initial codes with eight child codes were used to code the data; we re-read, re-coded, and unpacked the data to synthesize and interpret for reporting.

Criteria	Possible Appraisal Points	Appraisal Points Given
1. Research Problem, Purpose, and/or Question	2	
a) Problem is stated clearly and related to the research literature		
b) There is a clear statement of research purpose and/or question		
2. Method: Data Collection and Analysis	6	
a) Study is methodologically qualitative i) Sample plan and data collection are appropriate to the question ii) Data analysis plan is consistent with design and purpose		
b) Described the participants of the study and how they were selected		
c) Researcher showed an awareness of their influence on the study and its participants (describe experiences and/or assumptions with which the researcher entered the research)		
d) Data collection procedures are fully described		
e) Steps/process of the data analysis is clear with examples		
f) Techniques for credibility and trustworthiness are described and used correctly		
3. Findings	5	
a) Interpretations of data are plausible and/or substantiated with data		
b) Overall findings address the purpose of the study		
c) Ideas (themes, categories, concepts, etc.) are precise, well developed, and linked to each other		
d) Results offer new information about or insights into the targeted phenomenon		
e) Quotes provide support/evidence for each theme/concept presented		
4. Discussion and Implications	2	
a) Return to the research questions/purpose proposed at the beginning and discuss interpretations and significant findings		
b) Recommendations for intended audience and future research issues		
Total Point	15	
High overall standards of quality and credibility = 11-15 points. Moderate overall standards of quality and credibility = 6-10 points. Low overall standards of quality and credibility = 0-5 points.		

Figure 2: Appraisal Rubric

Data Analysis

Throughout every step within this process the two authors initially worked separately. We then came together to negotiate the retention of articles and our findings, documented within an audit trail. For instance, once we determined our search terms in EBSCO, we separately mined through the 1,224 articles, prior to collectively deciding which articles met our criteria from those which we had both selected. Once we determined the 12 articles that would be treated as informants for this qualitative metasynthesis, all 12 articles were read and re-read by each researcher to note emerging themes. We met to negotiate the themes and to identify initial codes. Our initial codes lacked specificity (especially the one noted as *mathematics instruction*), and so our definitions were revisited and articles were re-coded. We periodically determined two to three articles to double-code on Dedoose, and we later met to negotiate the codes from each article in its entirety to ensure credibility; all articles were coded in this way. Following the coding process, we examined the excerpts identified for each code across the 12 articles to unpack our findings and to determine mathematics teaching practices that support CRP and CRT in pre-kindergarten through 12th grade.

Findings

Twelve articles were synthesized to understand how researchers interpret mathematics teaching practices that support CRP and CRT in pre-kindergarten through 12th grade. There were five findings: a) caring; b) knowledge of contexts and teaching practices using contexts; c) knowledge of cultural competency and teaching practices using cultural competency; d) high expectations; and e) mathematics instruction/teacher efficacy and beliefs. The five findings focus on teacher practices, classroom interactions, and student experiences with CRP and CRT within mathematics education.

Caring

Caring is a continuous cycle of working to establish a rapport, using knowledge gained from that rapport to inform teaching practices, and then, reflecting upon teaching and learning to understand learners' mathematical knowledge. Caring was demonstrated in the ways in which teachers created positive learning environments where learners saw themselves as participatory; teachers took an active role in seeking out knowledge about learners and communities; and teachers supported learners emotionally and academically by making mathematics content accessible and empowering learners mathematically. In the following excerpt, we see the significance of teacher-student relationships and how that translates into mathematics instruction.

> When establishing relationships, teachers cannot merely go through the motions because students know when teachers are genuine and really care about them. African American students must relate to the teacher and the teacher must relate to them. The teachers realize they must have a relationship before they can make mathematics lessons relevant to the students. They take the opportunity to know their students and discover their motivations and interests. They tailor their instruction with this knowledge. (Jackson, 2013, p. 7)

Although caring is not specifically noted as a tenet of CRP or CRT, it is clearly evident within the dialogue surrounding the tenets. For instance, Gay claims that CRT is multidimensional, for which a key dimension includes fostering positive student-teacher relationships. Likewise, CRP places emphasis on the teachers having respect for learners' culture. "Respect" was noted as one of our vocabulary terms which indicated a caring rapport.

Context

In addition to developing rapports with learners, context played a crucial role in making mathematics relevant and accessible. *Context* incorporated two dimensions as seen in *knowledge of context* and *teaching practices and strategies that use context*. Knowledge of context is related to space and place in the ways teachers gained knowledge of their students' home-life, communities, and neighborhoods. In the following excerpt, we see how Ms. Finley gained knowledge of context.

> Ms. Finley often "walk[ed] the neighborhood," taking time out in the evenings to visit with students and their families. She knew that this type of connection with the community was important, and she was able to weave the knowledge that she gained through these interactions into the mathematical content that was the basis for her lessons. (Bonner & Adams, 2012, p. 30)

After the teachers sought out knowledge, they integrated mathematics instruction and knowledge of context by making meaning of the mathematics curricula and tasks. Teachers were actively engaged in communities to work with learners' parents and families for mathematizing contexts, creating and adapting mathematical problems, utilizing questioning strategies to elicit learners' local knowledge, requiring explanation and justification as it relates to context knowledge, and creating project-based opportunities incorporating funds of knowledge. Gay states that CRT is *validating* and should build bridges between school and learners' homes; essentially, the presence of this bridge is how we have defined *context* and the findings that support the presence of *context*.

Cultural Competency

Cultural competency was found in the ways teachers developed knowledge and skills associated with various forms of communication and funds of knowledge. Further, the teachers acted on this knowledge of cultural practices by incorporating such knowledge into their teaching practices. Teachers promoted engagement by incorporating nonverbal communication through proximity and by integrating music and movement into teaching practices. The teaching practices and strategies primarily focused on classroom discourse including storytelling, utilizing call and response, and dynamic forms of interactions. Teachers made mathematics accessible by unpacking and connecting cultural artifacts.

In the following excerpt, we see how Inga engaged in interviews with her learners to develop an informed understanding of her learners' cultural practices and funds of knowledge as it relates to shopping and currency.

> …From this, Inga learned about her students in ways she did not expect, finding that those students who shopped with their families were able to quickly solve problems regarding currency. These students demonstrated a remarkable facility with these transactions that suggest they had powerful strategies for dealing with the situation. Although Inga learned much about her students' interaction with money when outside of school, she could have taken this further by exploring the specific strategies they used. The strategies children use with money are often non-routine, and this might have offered an opportunity to gain a deeper knowledge of students' understanding. (Wager, 2012, p. 16)

As previously mentioned, the findings for cultural competency strongly aligned with the ways in which Ladson-Billings unpacked cultural competency with CRP. Additionally, this finding also

ties into CRT and how it *validates* learners' cultural heritages in such ways that teachers build cultural practices into classroom instruction.

High Expectations

Teachers must have *high expectations* both for their learners and for themselves. Teachers made necessary teaching revisions based on their learners' needs, interests, and understandings as they relate to mathematics. There was a level of flexibility and impromptu teaching that was evident with the teachers who were most capable of reaching their learners. Furthermore, teachers were warm-demanders who established learning environments in which learners were held accountable and empowered by taking an active role in their own learning; we see these practices within the context of Ms. Bradley's classroom.

> … Ms. Bradley's classroom was highly structured and disciplined, focusing on high expectations and success through "tough love." When a student did not have his or her homework, for example, Ms. Bradley would take the student in the hallway to call his or her parent or guardian…Ms. Bradley explained that this type of discipline is "what they get at home from their mama or grandmamma—you can't mess around." Furthermore, she indicated that this type of culturally connected communication and maintenance of high expectations allowed students to develop racially and culturally "so that they don't have to give up what they are used to for the sake of passing class...they have to do this in other classes and I'm not going to teach them to be White." (Bonner, 2014, p. 395)

This excerpt specifically demonstrates how the finding is not just about having high expectations for learners, but rather how those expectations are culturally connected to learners' lived experiences. The conceptualization of high expectations is seen both in CRP by focusing on academic achievement and in CRT by focusing on the comprehensive achievement of the whole

child. Additionally, both frameworks advocate for teaching practices that support students in realizing that achievement is within their reach, translating into student empowerment and self-determination.

Mathematics Instruction

Mathematics instruction highly correlates with teaching practices and strategies for both context and cultural competency. The findings are specific to mathematics teaching practices and incorporate aspects which are indicative of high-quality mathematics instruction. For instance, teachers utilized technology, incorporated tools and manipulatives in their instruction, and engaged in modeling their thinking for learners. It is important to keep in mind that we are not claiming that when one practices high-quality mathematics instruction that he or she is engaging in CRP and/or CRT; rather, when a teacher has high confidence in teaching mathematics and high self-efficacy, believing that mathematics instruction should be student-centered, open-ended, inquiry-based, highly interactive, and impromptu, based on learners' needs and interests, CRP and CRT are more likely to occur. When teachers felt confident with mathematics, they were more likely to create opportunities for their learners in which they were able to take ownership of their own learning and make personal connections to the content. In the following except, we see Chela make relevant connections to everyday classroom experiences and mathematics.

> … Chela loved math. Chela turned this passion for math into a professional strength—she took advantage of all math professional development opportunities and she made mathematics a central part of her practice. Unlike many of her peers, Chela didn't have a math center or a math time—that seemed silly to her, as math was everywhere. Weaving math into daily activities was what Chela did best. As she designed different games or

> visual supports she looked for the math hook. For example, Chela used 10 frames in attendance… a typical opportunity for name recognition and counting; extending the activity in several ways that deepened learning opportunities. (Graue, Whyte, & Delaney, 2014, p. 308)

Within the excerpt, the mathematics instruction is explicit as we see Chela using mathematical tools such as ten frames, which are two-by-five arrays often used to help students learn to subitize, to connect the mathematics instruction to everyday activities and practices like student attendance. Though this finding is specific to mathematics teaching and learning, it does relate to the theoretical framework for CRT in that it calls for transformative education that defies traditional educational practices.

Discussion & Implications

As with any synthesis of literature, this piece is time sensitive. This work specifically examines articles that were on the EBSCO database up until February of 2016. Thus, since data collection, surely more papers have been published which would fit our inclusion criteria, but performing a qualitative metasynthesis is simply a laborious process that demands an extensive amount of time to appropriately analyze the data. Such process requires at least two researchers who have some knowledge of literature and who understand the nuances necessary to make decisions throughout the process. In our case, we made decisions to focus on peer reviewed articles, negotiated codes, and negotiated the appraisal process. Because we focused only on peer reviewed articles, researchers can build from the work to examine book chapters, dissertations, and non-peer reviewed works. Our contribution to the field of mathematics education is providing one frame from which qualitative metasynthesis can be conducted.

There is a dearth of research focused on unpacking mathematics teacher actions focusing on CRP and CRT. While Ladson-Billings and Gay provide frameworks for CRP and CRT, there appears to be inconsistent ways in which these frameworks are interpreted in mathematics education research. There are inconsistent interpretations on whether mathematics or culture should be centralizing agents. There were examples in which the research documented teaching practices of simply changing the context of mathematics tasks to reflect the cultures of learners. There were examples in which the research documented teaching practices mathematizing elements of contexts and communities to highlight social justice issues. A critique of the body of work is that very little research documented sociopolitical consciousness and critical consciousness. It is not clear whether critical consciousness is central in mathematic teaching using these frameworks.

More work is needed in the field to unpack teaching practices that promote access, equity, and empowerment. The findings of this research suggest that teachers who incorporate CRP and CRT know their learners and the communities of their learners. More work is needed to unpack the continuous cycle teachers use to develop rapport with learners and communities. It is not clear in what ways contexts and support within schools and communities are central elements in CRP and CRT. That is, what are the kinds of supports teachers needs to draw on to incorporate elements for funds of knowledge and communal aspects? The findings from this work suggest that mathematical knowledge for teaching positively impacted teachers' lens for CRP and CRT; more work is needed to understand and unpack the interactions of teachers' knowledge of context and culture with knowledge of mathematics and teaching mathematics.

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Manuscript Two

One University's Story on Teacher Preparation in Elementary Mathematics: Examining Opportunities to Learn

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Abstract

This multi-case study examines how three elementary mathematics methods instructors, in the same teacher education program, provide their teacher candidates with learning opportunities. Data were collected through interviews, classroom observations, and artifacts. The findings suggest that the instructors' beliefs associated with teaching philosophies influence both the content that teacher candidates have the opportunity to learn (*what*) and the nature of the teacher candidates' opportunities to learn (*how*). Through analytic induction, three assertions were developed to understand and explicate: similarities in opportunities to learn, differences in opportunities to learn, and perceptions about the purpose of the methods courses across the three cases. Specifically, the first assertion examines how all three methods instructors focus on developing conceptual understanding and combating mathematical misconceptions for which teacher candidates most often experience opportunities to learn through representations and approximations. The second and third assertions place more emphasis on differences across the cases based upon observed instructor actions and their perceptions. This study is significant because it helps us gain a deeper understanding about teacher candidates' opportunities to learn within one teacher education program, and therefore, may point toward what can be done in the future to better prepare teachers in elementary mathematics education and the development of high-quality instruction. Additionally, this study unpacks how pre-service teachers in the same teacher education program may have varying experiences and thus varied access to opportunities to learn.

This multi-case study is part of a longitudinal study that focuses on pre-service teacher preparation in elementary mathematics and English Language Arts (ELA) in a large-scale study involving six preparation programs across three states; a primary focus is on novice teacher perceptions about their experiences and learning opportunities in their programs. This study specifically examines how elementary mathematics methods instructors provide teacher candidates (TCs) with learning opportunities within their courses. Recent literature (e.g., Lampert et al., 2013) unpacks ambitious pedagogies in mathematics teacher education; yet, as documented by Clift and Brady (2005), there is still much to learn about the various instructional strategies employed by mathematics methods instructors as well as the learning opportunities afforded to TCs (Cavanna, Drake, & Pak, 2017). Therefore, the study reported here is significant because it helps us gain a deeper understanding about TCs' opportunities to learn (OTL) ambitious pedagogies within one teacher education program, and therefore, may point toward what can be done in the future to better prepare teachers in elementary mathematics education.

The focus of this study is on instructional strategies, used synonymously with teaching practices, from multiple perspectives including: a) the instructional strategies method instructors are using in their own courses; b) the various ways in which TCs are engaging with such instructional strategies in their methods courses; and c) the ways in which instructional strategies introduced by the methods instructors help TCs to make meaning of what it will be like to be teachers in the near future. This research unpacks both the content that TCs have the opportunity to learn and the nature of the TC's opportunities to learn across the different cases (methods instructors). The findings are summarized by three assertions which examine similarities in OTL for TCs across the cases, differences in OTL across the cases, and the methods instructors' perceptions about the purpose of the methods courses.

Literature Review

In mathematics education research, ambitious instruction and standards-based teaching practices are often used together or in place of one another. Within the Literature Review, I examine these constructs and move toward discussing how observation measures of standards-based teaching practices, such as Mathematics-Scan, can be utilized to observe for ambitious mathematics instruction. Therefore, we can draw upon such measures qualitatively to examine the ambitious practices of elementary mathematics methods instructors. Provided that the instructors' teaching practices translate into observable actions that provide learners with opportunities to engage in mathematical practices or behaviors, we can further discuss TCs having OTL ambitious instruction. Furthermore, aligning with literature on beliefs, this study suggests that TCs' OTL are highly influenced by their instructors' beliefs about effective mathematics teaching practices.

Ambitious Instruction

The construct of ambitious instruction is well supported in the literature on teaching (Franke, Kazemi, & Battey, 2007; Grossman, Cohen, Ronfeldt, & Brown, 2014; Lampert, Boerst, & Graziani, 2011; Thompson, Windschitl, & Braaten, 2013). The larger, longitudinal study, under which this study is nested, operates under the following definition for ambitious instruction:

> We conceptualize "ambitious instruction" as comprised of a set of teaching practices that foster students' deep, conceptual understanding of academic content. Rigor is the hallmark of ambitious instruction. It is visible in the tasks the teacher selects, the ways in which the teacher supports students in engaging in those tasks, and the ways in which the teacher responds to what students think and do (Kazemi, Franke, & Lampert, 2009).

> Ambitious instruction provides students opportunities to participate in reasoning and argumentation, to actively make sense of academic tasks, and to develop disciplinary practices from considering one's audience when composing text to comparing solution methods in mathematics. Teachers focus students on the intellectual processes that support them in tackling demanding tasks, pushing students to justify their approaches to tasks and pressing them to elaborate on their explanation and clarify their thinking. (Spencer Reviews)

Furthermore, it is important to acknowledge that ambitious pedagogies are often used interchangeably with standards-based teaching practices (e.g., Lampert et al., 2010).

Standards-Based Mathematics Teaching Practices

Standards-based refers to teaching practices that provide learners with opportunities to engage in mathematical practices or behaviors (e.g., math discourse, representation) as outlined in the National Council of Teachers of Mathematics process standards (NCTM, 2000; Walkowiak, Berry, Pinter, & Jacobson, 2018). These process standards focus on problem solving, reasoning and proof, communication, connections, and representation. Such teaching practices also capture more recent standards (e.g., mathematical modeling and argumentation) in the United States released by the National Governors Association Center for Best Practices and Council of Chief State School Officers (2010) (Walkowiak et al., 2018). All of these standards focus on teaching practices that support conceptual understanding. Numerous observation measures have been developed to measure for standards-based mathematics teaching practices including Mathematics-Scan.

Mathematics-Scan and Ambitious Instruction

Mathematics-Scan (M-Scan) is an observational instrument that measures the extent to which instruction includes standards-based mathematics teaching practices that are characterized by students' opportunities to engage in mathematical behaviors as outlined by standards documents (e.g., NCTM, 2000) (Walkowiak, Adams, & Berry, 2019). Walkowiak and colleagues (2018) note that although the vision for M-Scan was grounded in *Principles and Standards for School Mathematics* (NCTM, 2000), the measure highly overlaps with *Principles to Actions* (NCTM, 2014) that was published after the development of the instrument and outlines the "eight effective teaching practices." Lampert et al. (2010) claim that the vision in these NCTM documents outlines ambitious instruction (Walkowiak, et al., 2018). Furthermore, Walkowiak et al. (2018) state that "the four domains of M-Scan are tightly connected to these… features of ambitious instruction" (p. 462). The four domains of M-Scan include: task selection, use of representations, discourse, and coherence; the domains further break down into nine dimensions (as seen in Table 1). This study draws upon M-Scan as an observation measure given its emphasis on students' opportunities to engage in ambitious pedagogies in mathematics education.

Opportunity to Learn

The definition for OTL has varied substantially since the 1960s. Carroll (1963) "defined OTL as the amount of time allocated to the learner for learning a specific task (Tate, 2001, p. 1019). Husén (1967) referenced to OTL as how accurately the curriculum taught matched that "assessed by achievement tests" or the quality of the instruction (Tate, 2001, p. 1019). Tate (2001) focuses upon how time, quality of instruction, and technology influence students' understanding of science. Furthermore, Tate and colleagues (2012) discuss how OLT has

traditionally (e.g., Tate, 2001; Tate & Rousseau, 2007) focused upon content exposure and coverage, content emphasis, and quality of instructional delivery, yet other factors such as time and quality factors linked to science, technology, engineering, and mathematics (STEM) education need to be explored. Additionally, Schmidt, Cogan, Houang, and McKnight (2011) claim that content coverage variation across districts and states has the largest impact on a student's opportunity to learn which effects academic achievement. Although these studies look across different variables that influence OTL, they are broadly concerned with factors that impact students' understanding within a discipline (or across disciplines) that translates into their academic achievement.

While there is variability in definitions for OTL, this study aligns with that of the longitudinal study and operates under Schmidt and colleagues' framework for OTL, defining it as, "the content to which future teachers are exposed as a part of their teacher preparation programs" (Schmidt, Cogan, & Houang, 2011, p. 140). This framework differentiates the content that TCs have the OTL within their mathematics teacher preparation coursework based upon four categories: mathematics, mathematics pedagogy, general pedagogy, and practical experience (Schmidt, Blömeke, et al., 2011; Youngs & Qian, 2013). Therefore, this framework for OTL aligns with the purpose of the study, which is to examine TCs' OTL ambitious teaching practices in elementary mathematics methods courses, and is concerned with factors that impact TCs' ability to demonstrate expertise within the teaching profession. OLT is observable based upon the actions and teaching practices of the instructors and the behavior of the TCs. This study examines both the content (what) that TCs have the OTL and the nature of the TCs' learning opportunities (how).

Examining Learning Opportunities

What teacher candidates have opportunities to learn. In addition to being competent with indicators of ambitious instruction and standards-based teaching practices, TCs should have learning opportunities that facilitate in the development of mathematics knowledge for teaching (MKT). The development of MKT for TCs is foundational to teaching for conceptual understanding.

Mathematics Knowledge for Teaching. There has been an ongoing discussion about a gap in knowledge for how to best prepare pre-service teachers (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2009), specifically in mathematics education. Deborah Ball fostered this discussion by elaborating on how preparation should focus on mathematics content knowledge (MCK) and pedagogical content knowledge (PCK). Ball (1990) expanded upon the work of Shulman (1986) with content knowledge and his conceptualization of PCK by adapting the theoretical framework to mathematics specifically. MCK has been defined as, "a comprehensive understanding of breadth, depth, connectedness and thoroughness" of mathematics (Ma, 1999; Hine, 2015b, p. 2). PCK is defined as, "knowing a variety of ways to present content and assisting students in deepening their [mathematical] understanding" (Hine, 2015a, p. 483).

More recently, there is increasing support for developing mathematics knowledge for teaching (MKT) with teacher candidates, especially in elementary education (Delaney, Ball, Hill, Schilling, & Zopf, 2008). MKT incorporates PCK and subject matter knowledge (SMK). Within MKT, SMK is inclusive of common content knowledge, specialized content knowledge, and horizon content knowledge, and PCK includes knowledge of content and students, knowledge of content and teaching, and knowledge of content and curriculum (Ball, Thames, & Phelps, 2008).

Developing MKT in TCs is foundational to their readiness to teach elementary students for deep conceptual understanding and examining mathematical misconceptions.

Teaching for Conceptual Understanding. The National Research Council (NRC; 2001) acknowledges the evolving, historical meaning for "successful mathematics learning" (p. 115). In particular, the NRC (2001) states that during the first half of the 20th Century, success was defined by the usage of computational procedures of arithmetic; particularly in pre-kindergarten through eighth grade. Though there have been numerous movements in how success is defined since that time, when references are made to "traditional" mathematics, they are generally acknowledging a dominant, historical emphasis on procedures, memorization, and formulas (NCTM, 2014; Barkatsas & Malone, 2005). NCTM (2014) claims that beliefs from the "traditional lesson paradigm" are unproductive when they hinder effective teaching practices and limit students' OTL (p. 9). In contrast, NCTM (2014) advocates for productive beliefs that align with ambitious instruction as seen within the "eight mathematics teaching practices." Likewise, the NRC (2001) claims that for anyone to successfully learn mathematics, he or she must develop *mathematical proficiency*, inclusive of: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition (stands are interwoven and interdependent).

There is a focus in mathematics education (e.g. NCTM, 2017; NRC, 2001; Garofalo, 1992) to teach for conceptual understanding, which has been defined as, "an integrated and functional grasp of mathematical ideas" (NRC, 2001, p.18). Teaching for conceptual understanding means that teachers have to be prepared to confront mathematical misconceptions by discouraging the use of isolated facts, methods, and rules for the sake of efficiency (e.g. Cardone & MTBoS, 2015; Karp, Bush, & Dougherty, 2014). For example, "rules" such as

"always take the bigger number minus the smaller number" that appear in instruction can create mathematical misconceptions and become problematic when students progress to more advance mathematics where the rule expires (like with the introduction of integers). Sometimes, teachers may not even recognize how they are supporting misconceptions because these practices are so entrenched in traditional mathematics teaching practices, currently being challenged. Teaching for conceptual understanding drives ambitious instruction and standards-based teaching practices.

How teacher candidates have opportunities to learn. Two *pedagogies of practice* emerging from the work of Grossman, Hammerness, and McDonald (2009) include *representations* and *approximations.* Cavanna et al. (2017) define representations as teachers (pre-service and/or novice in-service) having the opportunity to watch and/or read about others engaging in teaching practices. Therefore, representations occur through modeling, generally by a mentor or instructor, watching teaching videos, looking at vignettes, and/or other forms of observation. It is important to note that such representations are different than mathematical representations such as symbols, graphs, pictures, words, charts, diagrams, and physical manipulatives used to demonstrate mathematics concepts (Berry et al., 2017). *Approximations* entail having safe places to practice what TCs will actually be expected to do as teachers (Grossman et al., 2009). Approximations can appear in various forms such as: practicing classroom management, teaching episodes, creating and/or grading assessments, making lesson plans, and there are certainly many others that could be added to this list.

Influence of Instructor Beliefs on TC's Learning Opportunities

Questions surrounding the influence of teachers' beliefs upon their teaching practices has been ongoing area of research in mathematics education. The National Council of Teachers of

Mathematics (2010) stated that "Teachers' beliefs influence the decisions that they make about the manner in which they teach mathematics" (p. 10). Philipp (2007) defines beliefs as "psychologically held understandings, premises, or propositions about the world that are thought to be true," and that are generally organized into belief systems based upon similar constructs or ideas such as effective mathematics teaching (p. 259). Cooney, Shealy, and Arvold (1998) state that when examining belief structures, "the constructs of quasi-logical and psychological strength are quite different" (p. 309). Thus, method instructors may believe that it is important to provide TCs with learning opportunities to use mathematical manipulatives, but if the psychological strength of this belief about mathematics teaching practices is not strong, then they may not follow through with creating learning opportunities within the classroom. This is important within this study because psychologically strong beliefs of the instructors' directly impact OTL for TCs. Likewise, just because a belief has strength in one context does not mean that it will have as much strength in another context (Cooney, Shealy, & Arvold, 1998). In their literature review, Bishop, Seah, and Chin (2003) examine the various ways in which researchers identified differences and similarities between beliefs and values. Building upon this literature review, I am using the terminology belief (as opposed to values) based upon the context-dependent nature of judgements made about best teaching practices. Likewise, I take the position that beliefs are more cognitively ingrained and are harder to change than attitudes and perceptions (Phillips, 2003).

For beliefs about mathematics teaching practices, I am examining instructor beliefs about the content that should be taught and the ways in which such content should be delivered. Thus, when examining how method instructors' beliefs about mathematics teaching practices impact instruction and TCs' OTL, this study considers both what the instructors were saying and what

was observed in their actions. Therefore, in the findings (Assertions 1 and 2), this study specifically reports on instructor beliefs that were considered psychologically strong (given enactment in their instructional strategies), supported with evidence, and demonstrated consistently within the actions of the participants. The instructors' beliefs about mathematics teaching practices manifest in their actions during their own instructional strategies, and such actions result in OTL for TCs. This is significant because we can begin to understand how instructors' beliefs impact their instructional choices surrounding content (coverage and exposure) and how that in turn influences TCs learning opportunities as it relates to content.

Purpose & Research Questions

The purpose of this study is to examine TCs' opportunities to learn ambitious pedagogies in elementary mathematics methods courses at Robins University (pseudonym). Specifically, this study is focusing upon the learning opportunities for TCs that stem from the instructional strategies used by their methods instructors. Furthermore, this study takes into consideration the ways that instructor beliefs about effective mathematics teaching practices influence TC's OTL. My research questions include the following:

- What instructional strategies do the three elementary mathematics methods instructors implement and which strategies lead to learning opportunities for teacher candidates?
- How do instructor beliefs about effective mathematics teaching practices influence learning opportunities for teacher candidates?
- How do these elementary mathematics method instructors perceive the purpose of elementary mathematics method courses?

Methodology

Access and Role Chosen

During the Spring of 2017, I was asked to work on the longitudinal research project that focuses on the development of *ambitious instruction* in elementary mathematics and ELA. That study has tracked more than 150 elementary TCs from six teacher preparation programs in three states (in Northeast, Midwest, and Southeastern United States) into their first, second, and now, third year of teaching. My assignment over the summer of 2017 was to focus on one of the cooperating universities and reach out to methods instructors for interviews to discuss their course content and instructional strategies. During these interviews, I became curious as to how the actual or observed instruction of these instructors might compare to their self-reported accounts. This curiosity stemmed from their stated beliefs surrounding effective teaching practices.

Site and Sample

Robins University is nestled in a southeastern state located in a rural city (population of 50,000), and it is known for its large teacher education program. The sample for the summer interviews included five methods instructors (three mathematics and two ELA) and two individuals in administrative positions. For the purpose of this work, I have chosen to primarily focus on the sample of elementary mathematics instructors due to my interest in mathematics education. It should be noted that all of the instructors are White, and they have all taught at the elementary level prior to becoming methods instructors, and their ages range from late-30s to late-50s.

The names of these instructors are William, Brittany, and Megan (pseudonyms). In regards to the participants' level of education: William has completed his M.Ed. and was

nationally recognized as an exemplar elementary teacher prior to coming to Robins as an instructor; Brittany is an associate professor with her Ph.D.; and, Megan is an assistant professor with her Ph.D. It should also be noted that the elementary mathematics methods instructors taught two different courses throughout the semester: *Mathematics Education for Children I* and *Mathematics Education for Children II*. These are consecutive courses taken during TCs' fourth and fifth years in a five-year teacher education program. To incorporate multiple perspectives, I also drew upon the voices of the two administrators, Sadie (coordinator of the elementary education program) and Chelsea (elementary department head).

Data Gathering Procedures

Interviews. Prior to performing classroom observations, I interviewed all three of the elementary mathematics methods instructors. Email was utilized to contact each instructor directly to arrange these interviews which occurred during the summer via FaceTime. An interview protocol was used to guide this interviewing process (as seen in the Appendix). The interviews were all recorded and transcribed, allowing for member checking, and they ranged from 60 to 90 minutes with each participant. These initial interviews served as preliminary data and helped to focus the observations, provided that I was originally interested in examining how the instructors' personal accounts of their instruction compared to their observed instruction.

Following classroom observations, additional interviews were scheduled. The second round of interviews was necessary to have the instructors further unpack some of the instructional strategies and learning opportunities that were noted within the observations. These interviews were all approximately 45 minutes each, and were conducted remotely, using FaceTime. Additionally, two of the administrator interviews were conducted in person with one of the Principal Investigators (PI) for the larger study; he recorded both of these interviews and I

transcribed the data for analysis. Further, I conducted a second 30 minute, in person interview with Sadie to further unpack her role at the institution. These interviews speak to the context and the alignment within the teacher education program.

Classroom observations. Throughout the 2017 Fall semester, I conducted eight classroom observations of the three elementary mathematics method instructors, accounting for 20 cumulative hours. The intent was to observe all three instructors for the same amount of time, but due to scheduling conflicts, the break-down of the observations included: three classes with William; three classes with Brittany; and, two classes with Megan. The courses were at various times, on different days of the week, yet all classes were two and a half hours long. During each observation, I took detailed double-column fieldnotes, both describing the instructors' actions and their students' reactions to such instruction. I generally attempted to transform these fieldnotes into write-ups on the same day that the observation occurred. An observation protocol drawing upon M-Scan and indicators of ambitious instruction was utilized to keep the study's purpose at the forefront.

Other reportable events and documentation. Lastly, I was able to utilize "other reportable events" as data. "Other reportable events" in this study include informal conversations with the participants, e-mail correspondences, and/or brief scheduled meetings with participants. Further, while I was in the field observing classroom instruction, the methods instructors provided me with copies of handouts used in instruction and I received their consent to take pictures of some of the activities, student artifacts, and components of interest.

Researcher Positionality & Researcher as Instrument

As a former mathematics teacher, I am invested in work that focuses on teaching practices in prekindergarten through 12th grade which make mathematics more accessible,

equitable, and empowering for learners. Therefore, I find value in teacher education programs that provide TCs with opportunities to learn ambitious mathematics teaching practices. It should be disclosed that my advisor is one of the developers of M-Scan, and so, because of my training with this observation measure, I was originally asked to join the research team for the longitudinal project.

Given that this is an interpretivist study, it is pivotal that I acknowledge my role as the researcher as instrument. As the instrument, I both administered the protocols and made interpretations of the data throughout every step of the process. Thus, as Emerson, Fretz, and Shaw (1995) account, my own "assumptions, interests, and theoretical commitments enter into every phase of writing…and influence decisions that range from selecting which events to write about to those that entail emphasizing one member's perspective on an event over those of others" (p. 167). Though social science work is by its very nature subjective, I have tried to best of my ability to engage in a systematic reflective and iterative process, in which I confronted my own assumptions and triangulated data (Erickson, 1986). I did not come into this work grounded in theory (Corbin & Strauss, 1990), but instead have tried to let the data generate theory.

Credibility

Based on my unique "insider" and "outsider" perspective, I do believe that my own positionality could be seen as a strength of credibility in this study. I am very much an insider having been a mathematics teacher, having a degree in mathematics, and being a doctoral student. On the other hand, I am an "outsider" because of my lack of familiarity with the teacher preparation program at Robins University. Thus, I have the ability to interpret these data in a distinct way. On another note, it should be acknowledged that although I did not attend Robins University, I grew up within the area and later taught in the same county for which many of the

TCs are being sent to for practicums and student teaching. This insight enables me to be invested in and knowledgeable about the TCs' experiences outside of the classroom. I kept a methodological journal documenting the entire process and decisions made along the way, which was essential for the sake of keeping an audit trail to ensure trustworthiness. Further, I attempted to adhere to Erickson's (1986) suggestions for maintaining and establishing credibility.

Data Analysis Procedures

This study drew upon Erickson's (1986) model of analytic induction. As indicated in my methodological log, following each observation, fieldnotes were transferred into write-ups, and all of the audio from the interviews in the first round were transcribed. From write-ups, transcripts, and other reportable data and documentation, analytic memos were written intermittently to document emerging themes and inferences. The audio from the second round of interviews was listened to repetitively to document inferences and supporting evidence which appeared in my final analytic memo. Data sources were triangulated and re-read and re-coded to document emerging patterns and assertions. I compared confirming evidence and disconfirming evidence for each emerging assertion and continued to adjust the assertion until all evidence was accounted for. I thought through assertions extensively including the connections between the assertions. Additionally, I engaged in peer debriefs to ensure trustworthiness. Throughout this inductive process, data were reduced to three assertions for the focus of this paper. In the findings, the assertions are supported with evidence in the form of quotes, observational data, vignettes, and documentation of other reportable events.

Findings

From the data analysis process, three assertions were developed to understand the following: similarities in opportunities to learn, differences in opportunities to learn, and perceptions about the purpose of the methods courses across the three cases.

Assertion 1: Similarities in Beliefs. Similarities identified in instructor beliefs associated with teaching philosophies led to parallels in *what* teacher candidates had the opportunity to learn as well as *how* teacher candidates had opportunities to learn.

***What* teacher candidates have the opportunity to learn.** In my time in the field, I began to notice that all of the mathematics elementary instructors were engaging in instructional strategies that were student-centered, open-ended, inquiry-based, and highly interactive. Although there were evident differences in instruction based on instructor beliefs (which will be unpacked in Assertions 2), all three instructors focused on teaching students for conceptual understanding, such that, at every observation, I saw instructors pushing back against teaching procedures and rules for the sake of efficiency. William claimed, "You have to slow down to go faster." All three instructors discussed how these "rules" or memory tools have to be accompanied with activities that build conceptual understanding, otherwise, they will lead to mathematical misconceptions, especially if the rules expire as the students advance through mathematics. The following vignette shows a typical interaction when unpacking mathematical misconceptions. Though the vignette addresses events evidenced in Megan's classroom, such instructional strategies were seen in William and Brittany's classrooms as well.

> Megan has just finished showing her students a short video clip about fractions. The video has upbeat music, jokes, and intriguing visuals, but the TCs are supposed to be debating its worth. The video sings a tune to the rule for changing a mixed fraction to an

improper fraction. So, for instance, when looking at $2\frac{3}{5}$, one must multiply two by five and then add three to get 13 for the numerator, and know to keep the same denominator, such that the answer becomes $\frac{13}{5}$. Megan shows another video of a student struggling to remember the rule, for the same task, the student ends up getting $\frac{11}{5}$ when she multiplies two by three, and then adds five, getting the incorrect numerator. A discussion follows the videos, but it becomes clear that the girl within the second video was taught a rule, without further instruction to build conceptual understanding. The TCs unpack what the teacher could have done differently.

When addressing the question, *what* are TCs having the OTL, teaching for conceptual understanding and combating mathematical misconceptions was by far the most emphasized content by all three participants.

***How* teacher candidates have the opportunity to learn.** The two most prevalent types of instructional strategies utilized were *representations* and *approximations*.

Representations. Representations were defined as modeling for TCs either effective or desirable ways to teach and/or modeling undesirable instructional strategies (typically followed by critique). Representations could come from video footage, audio, readings, and/or peer presentations. Thus, representations took various forms across the three classrooms. In the vignette that was previously presented, we see how Megan showed a video clip to get her TCs to critique instructional strategies that are based on memorization or rules that expire. However, just as Megan and her colleagues were seen incorporating representations to discourage certain teaching practices, they were more often seen modeling creative and interactive lessons that could be incorporated into the TCs' practicums, field placements, and/or future careers. Below is a vignette from Megan's classroom which models how TCs were provided with OTL through

representations (though there are certainly many other dimensions of ambitious instruction present).

> Megan has just dispersed manipulatives and supplies out to her students based upon table groups, which have three to four individuals. "Everyone gets either a piggy or a dinosaur and place your player anywhere on the game board." The game board is a labeled one hundred, square grid. The students have charts for documenting their scores. They are further instructed to put their three quarters, five pennies, and two dimes anywhere on the board, and to give each participant four cards, followed by placing the stack of cards in the center. The cards have integers on them and the students can use as many or as few as they want (within each hand; so, one to four) to try to land on a spot with money and collect a coin. The students are told, "Always redraw to have four cards in your hand at all times. Your goal is to get the most money!" The students play this game for about five minutes. Megan has Sesame Street music, from a YouTube source, playing in the background while they work. Megan uses a classroom management strategy to get the students to stop playing. For a short time, Megan breaks role playing, as do the students, and they discuss the benefits of having elementary children play such a game, including: disguising an integer lesson, practicing adding up the value of money, and using critical thinking skills. Then, Megan switches back into the role of an elementary teacher, talking about another game and how to play it. She tells the students that in this game, the piggies are the food source or the prey and the dinosaurs are the predators. Megan instructs, "The dinosaur picks his/her place on the board first. The dinosaur always has five cards and the piggy has six, and the piggy always goes first. This is a partner's game. If the piggy is still alive when I call time (5 minutes) then the piggy wins, otherwise, well

> otherwise, the piggy got eaten when the dinosaur landed on his/her square, so the dinosaur is the winner." The last couple minutes were filled with laughter, Sesame Street, and 20-year-olds who were able to pretend to be children if only for a while.

There are several aspects in this vignette which deserve to be unpacked. First, we see how Megan, the methods instructor, transitions into an elementary teacher. When she is modeling for the TCs, she models everything from how to pass out the manipulatives, the delivery of instruction, language and speech with elementary students, classroom management, and the creation of a welcoming, child friendly environment (with the music). Second, we see that the TCs react to such representations by embracing the role of being elementary students. Though I have chosen data from Megan's classroom to demonstrate how TCs were learning through representations, it is important to articulate that all three instructors were seen using such strategies. In fact, Megan shared with me that the games unpacked in the vignette came from William who had used them in his own teaching practices as an elementary teacher.

William often spoke about how vital these learning opportunities are for TCs; he believed that if they have had to engage in such instructional strategies as if they were elementary students, then they will be more prepared to meet the needs of their own students and have a more informed understanding when teaching. Of course, every TC will not test out all of the strategies and activities that they contemplate bringing into the classroom, but at least they are being provided with opportunities for which they can begin to think through how activities may be perceived by children.

Approximations. Approximations were defined as having students or TCs do tasks that they will be expected to do as teachers in the field. For William and Brittany's *Mathematics Education for Children II* courses, approximations most often appeared in the form of mini-

lessons. For the mini-lessons or teaching episodes, the TCs had to plan lessons (based upon a particular topic) and present them as if they were in the classroom with elementary students. William stated, "… [mini-lessons are] about giving you practical experience, not challenging your classmates…play the role that you think that you need to play. This is practice." In Megan and Williams's *Mathematics Education for Children I* courses, approximations often appeared in the form of planning for lessons, creating mathematical games, writing word problems and assessments, seeking out and critiquing specific curriculum resources, and various other classroom management strategies.

There were some differences in the ways that the methods instructors viewed the relationship between representations and approximations. For instance, William believed that the first course in the sequence should be more focused on representations with less approximations and that the second course (part II) should scaffold, being heavier on the approximations, relinquishing more responsibility. On the other hand, Megan felt like the two, representations and approximations, had to be balanced across both course levels, just with varying intensity.

As previously noted, in my time at Robins University, many of my observations captured the act of peer-teaching episodes. The following excerpt was taken from an observation in William's course for which the daily content and curriculum was focused on measurement.

> Natalie (TC) begins by passing out popsicle sticks and a worksheet to her "first-grade" students. She asks the students to join her on the carpet, while leaving their supplies at their desks. Next, she asks for a student volunteer to be the "object of measure." Jen volunteers and lays flat on the carpet while everyone else explores how many popsicles sticks in length Jen might be from head to toe. Natalie intentionally leaves gaps in the sticks to initiate a conversation, regarding whether this is a proper way to measure. Once

> they agree upon a length using popsicle sticks, Natalie informs them that they can go back to their desks and use popsicle sticks to measure the classroom objects indicated on the worksheet with a partner. While the students work collaboratively, Natalie walks around to assess progress. When she feels confident with their work, she gives them the rest of the worksheets; one has them measure using cubes and paper clips, and the other, includes pictures of classroom objects for which they are asked to estimate which object is larger and then compare actual measurements. (Observation, September 11, 2017).

Although this lesson was condensed due to the limited time that was available for each presentation, it was evident that Natalie had thought through and planned extensively for the lesson. In the mini-lesson that followed, another TC, Taylor, became unnerved as she realized that she had planned for the wrong mathematical content, liquid volume instead of length measurement. She had planned an activity to model the volume of a cup, pint, quart, and gallon. However, she was so anxious that she never taught, but just talked through what she would do, like discussing real world applications/connections and water pouring demonstrations. Then, Taylor suggested having her students use construction paper to build a "Gallon Man," for which she shared various images on the projector. Gallon Man or King Gallon is a memorization tool, which does not help students build conceptual understanding but simply memorize the difference between a gallon, quart, pint, and cup and their proportional relationship to one another. William was strategic about addressing this "tool" after the presentation. Later, William told me that he had never had a TC do so poorly.

Though it may not at first be clear, I chose to include evidence from both Natalie's and Taylor's teaching-episodes because such evidence speaks to potential differences in learning opportunities. William is purposeful in allowing his TCs to plan and make choices on their own

accord; he gives them little guidance unless they ask for it. Thus, in his course, he aims to structure practice which models the profession, and performing poorly highlights areas of improvement for which the goal is to work on such flaws prior to working with children. So, even though Natalie did well, demonstrating instructional strategies that she had previously learned, Taylor had a very different experience which highlighted areas of improvement. This created opportunities for Taylor to reflect upon her own performance as well as opportunities for William to think about what he could do to further help Taylor. Although Brittany also assigns teaching episodes in a very similar fashion instructionally, it became evident that she provides her students with far more support and guidance throughout the planning process (her focus on planning will be further unpacked in Assertion 3). Thus, with approximations, we have to be mindful of how much help TCs may be obtaining along the way and how this impacts their OTL.

Assertion 2: Differences in Beliefs. Differences identified in instructor beliefs associated with teaching philosophies led to differences in *what* teacher candidates had the opportunity to learn as well as *how* teacher candidates had opportunities to learn.

When the methods instructors were asked about their teaching philosophies, they each placed emphasis on different instructional strategies. Likewise, the observations revealed that even though the instructors collaborate extensively, they each have their own approach and beliefs which impact *what* and *how* TCs have the OTL.

Case 1: William. William taught third-grade for 11 years followed by one year with kindergarten students prior to beginning his career at Robins University. Thus, for William, his beliefs about teaching are highly influenced from his time working with children. He particularly elaborated on the desire to develop mathematical mindsets with his students and now TCs; he wants for them to see themselves as "Doers of Mathematics." Compared to the other instructors,

William placed greater attention on the NCTM process standards. In round two of the interviewing process, William mentioned how this focus on the NCTM process standards gives TCs a place to start as they reflect upon their own implementation of instruction as well as equip them with professional mathematical language. In the following observation, we see a TC present a lesson on angles such that her students are first tasked with exploring angle properties through visual illustrations. Through exploration and peer collaboration, the students collectively identify angles. The later part of the lesson includes an activity in which the students use protractors to measure angles taped to their desks. As the lesson comes to an end, we see the following:

> The presenter stands in the center of the room and reflects upon her performance, sharing her thoughts with William and her peers. Then, each table group, which has been preassigned an NCTM process standard, discusses feedback for the presenter. Individuals are responsible for writing down feedback on post-it notes, but there is also whole-class discussion for which each group shares their feedback directly with the presenter, as well as with the rest of the class. (Observation, September 25, 2017).

This observation excerpt is important because it models *what* the TCs were having the OTL as it relates to the NCTM process standards as well as *how* they were having OTL through feedback and reflection. For two of my observations (five hours in the field) with William, I saw this reflection and feedback process occur four times with various TC presenters; additionally, William claimed that this occurs with every TC. In this way, William intentionally created learning opportunities by having the TCs reflect upon their own teaching both informally and formally (the written submitted portion of this assignment), and by contemplating peer and instructor feedback following the lesson. The noteworthy part of this process is that often times,

peer feedback required the TCs to defend their instructional decisions and to think critically about the choices that they made and/or the revisions that they would make in the future.

Case 2: Brittany. Brittany is the eldest professor who has spent a great deal of time working in the field of mathematics education. Her personal journey in the field has taken a winding path; from her own accounts and her colleagues', this journey is still underway. Compared to the other two methods instructors, she places more value on MCK. When asked about her teaching philosophies and beliefs, she stated, "And I guess, this sounds really generic but I just want them to understand the math that they're teaching. And something else that's really important to me that I emphasize, I want them, if they're afraid of fractions or 3-D pieces, I want them to educate themselves about it." William made the following comment (about Brittany) when asked to address the alignment of teaching philosophies within the program, "I know there's a teacher or a professor who I have worked with, who in the years that I've been there, [I] have kind of helped shift her focus from teaching [more] content to more methods." It is pivotal to acknowledge that William was not claiming that content is not important, but rather that in the methods courses taught, there should be an emphasis on MKT as a whole. Especially since the TCs have to take three content mathematics courses prior to enrollment in *Mathematics Education for Children I*. Brittany's beliefs translated into *what* TCs had the OTL provided that it was more common to see Brittany going over and deriving traditional algorithms than the other methods instructors. In the following observation excerpt, we see Brittany trying to help her students understand the mathematical relationship of computing the area of various geometric shapes.

> Brittany draws a rectangle on the board and asks the TCs how they calculate the area of a rectangle. The TCs respond, "Area = length x width." Brittany proceeds to give them a

four by three rectangle to construct on their geoboards. After examining the area of the rectangle, Brittany prompts the TCs to figure out the area of the triangle created by the diagonal. This leads into a discussion about how the area of a triangle equals $\frac{1}{2}$ base x height or $\frac{1}{2}$ length x width when referencing back to the rectangle. Brittany gives the TCs a couple of "challenging" triangles on the geoboards to determine the area. Next, she models a parallelogram on the geoboard under the document projector (see Figure 1); she proceeds by drawing an interior altitude, creating a triangle and models how the triangle can just be moved (relates to transformations in discourse) to create another rectangle. This leads to the implication that they can find the area for a parallelogram using the same formula as that for a rectangle. Brittany continues on with the lesson by modeling a similar strategy for isosceles trapezoids (Figure 2) but then states, "trapezoids don't always look like this." So, she has the TCs work with a partner using their geoboards to examine an example of a trapezoid that is not isosceles, and they unpack the area formula once again as it relates to a rectangle (Figure 3). She then has the TCs go back to the area formula for an isosceles trapezoid and compare how it relates to a parallelogram (Figure 4). Brittany states, "If we are going to use formulas, we need to know where they come from." (Observation excerpt, October 3, 2017).

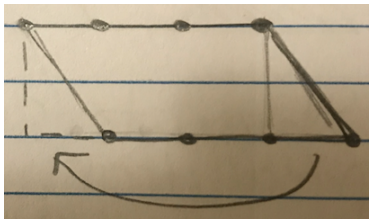

Figure 1

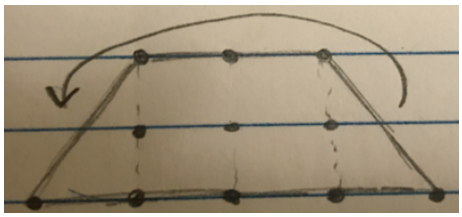

Figure 2

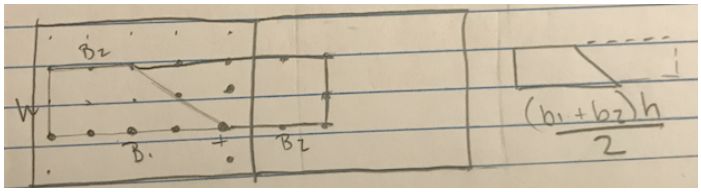

Figure 3

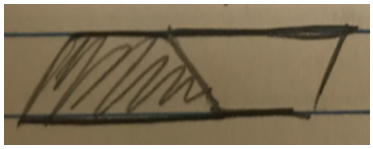

Figure 4

Although Brittany's beliefs about methods courses could be termed "traditional", given her tendency to place more emphasis on content and formulas, she talks openly about not wanting her students to fall into traditional forms of teaching, for which the mathematics is presented in a procedural manner without instructional strategies to support conceptual understanding.

> …I want them to know that they don't have to do it all their first-year teaching, but don't get caught in a rut because it's really, really easy to go back to the traditional way of teaching, because it's easy. I know, I did it. And I'm embarrassed. I'm glad that we didn't have social media back in the late 80s because I'd hate to think of what, you know, my students [would have said] and what a horrible math teacher I was.

From my discussions with her, I believe that Brittany intentionally tries to counteract her more traditional beliefs, which appears in *how* she provides TCs with OTL. For instance, she always incorporates a plethora of hands-on-activities that TCs could potential take directly into their own field placements. In many ways, these activities could be classified as representations which were unpacked in Assertion 1; however, they were distinct from those which appeared in

William's and Megan's courses due to range of content and pedagogy covered. For instance, Brittany was the only instructor who I observed deliberately trying to use technology (other than supplementary video clips) to support instructional strategies; she did a mini-lesson using applications on I-Pads to explore transformations of two-dimensional figures (after the TCs had explored such content using hands-on methods). Additionally, some of her lessons were interdisciplinary, showing TCs how they could integrate ELA and mathematics. An exemplar of this was when she had her students make their own tangrams and then create images using their tangrams from *Grandfather Tang's Story,* as Brittany read the story aloud.

Case 3: Megan. Megan stands apart from her colleagues because of her focus on research. When asked about her beliefs and teaching philosophies, she almost always draws upon literature in the field, and so, this literature is incorporated within the context of her courses; it becomes part of *what* the TCs have OTL. In the following excerpt, Megan discusses beliefs that she hopes to instill in the TCs.

> I do a lot of belief research, ... I liked Ernest 89's definition of beliefs in terms of mathematics. I want them to understand that it's a problem-solving approach, … it's a man-made skill where they can actually come together and construct for themselves, and there's multiple ways to be able to solve any problem. So, going off of that, and then their teaching, it's again from Ernest's framework. I like Liebman [and the notion of being a] facilitator where they basically, instead of lecturing up there at top, they actually work with their students. They actually understand how to get them to understand the topic through their own learning. I was teaching learning as an active construction of knowledge, and it's not a passive construction.

Notice that there are certainly similarities between all three of the instructors and how they discuss wanting their TCs to develop self-efficacy in their ability to teach mathematics, however, Megan continually makes these statements while referencing to research studies. Additionally, Megan's vision places more intent on the acceptance of multiple strategies and mathematical representations which not only appeared in *what* TCs had the OTL but also *how* TCs were provided with OTL. It is important to distinguish that r*epresentations* in this case is not referencing to the pedagogy of practice discussed in Assertion 1, but rather the presence of multiple mathematical representations used to demonstrate mathematics concepts (Berry et al., 2017). In Megan's classroom, TCs were instructed to work in small groups to develop their own word problems (based upon specified criteria) and then represent the problem-solving involved with various representations. Later, the small groups presented their problems and representations to the class. Photographs were taken to document and capture TCs' work samples. These presentations were very informal and were conversational in nature, but they provided an important space in which TCs could reflect upon what goes into facilitating ambitious mathematics instruction. The group work and presentations also created a link between research (their readings for class) and practice. This type of opportunity was a common occurrence in her course.

Assertion 3: The three methods instructors expressed a common purpose of seeking to influence their teacher candidates' mathematical mindsets. However, the methods instructors each expressed different (from one another) dimensions of ambitious instruction when interviewed about the purpose of the elementary mathematics methods courses.

Though there are certainly similarities across the three cases, as witnessed in their desire to influence TCs' mathematical mindsets (e.g., Boaler, 2016), there are noted differences in how the methods instructors talked about and acted upon the purpose of the methods courses. These differences have been unpacked by looking at each case or instructor separately in this assertion. However, it is important to note that even though the instructors emphasized certain dimensions of ambitious instruction more than others when discussing their course purpose, that does not mean that each of the instructors did not address all dimensions of ambitious instruction at various points throughout the semester. Even though this assertion focuses heavily on interview data, it also compares how participant interview data about course purpose compares to what was observed in the classrooms (which was unpacked in Assertions 1 & 2).

Case 1: William. When William was asked to discuss the primary purpose and objectives of his course, he discussed how he, "focus[es] on teaching through the NCTM process standards, problem-solving, [and] reasoning." Based upon William's beliefs, examined in Assertion 2, this is not surprising. However, after making the previous statement, William continued to discuss how he hopes that such instructional strategies will help his TCs develop a more positive perspective on what mathematics education can look like in the classroom. In the following excerpt, he comments on how many of the TCs in his courses have poor self-efficacy and mathematical mindsets due to their own experiences as students. For William, the challenge is to have his TCs develop growth mindsets and envision what mathematics can be.

> I'm trying to get our candidates … They come in a lot of them so like beaten down and [they] don't have a good mindset about what they can do mathematically, so I try to let them see that there are different ways to teach and this idea of teaching students by just forcing procedures on them isn't the way to go and let's make this an interactive

> environment. Let's let the students problem-solve and talk about what they're doing and focus on their ideas and their solutions, make math accessible to them that way...It's important that we kind of try to break this chain and give these kids, make them comfortable and confident with their ability to do this and you're just kind of steering the ship as the teacher.

Ultimately, William's account emphasizes how he hopes that his courses and instruction will contribute to breaking the cycle of fixed mathematical mindsets. He acknowledges that his TCs are products of their own experiences, but without an intervention, many of them would continue to teach mathematics with an emphasis on procedural knowledge and skills while simultaneously reinforcing the belief that only "some people are good at mathematics."

> I want you to walk out of my class with the idea of I wish somebody would have taught me math the way that you're saying we should teach math, so that when they get in, I tell them on the first day, "Look, I could put you all on a school bus right now and take you to the closest elementary school and you could all pick up the manual and stand in front of the class and have the kids follow a set of steps, a set of procedures, but that's not what we're here to do."

The previous quote is significant because it not only illustrates William's purpose for the class in regards to having his TCs strive to teach mathematics in ways that are more inquiry based, hands-on, and exploratory, focusing on conceptual understanding, but it also begins to highlight what William considers to be ambitious instruction. In the second round of interviews, William unpacked how his definition of ambitious instruction means having integrity or doing the right thing, simply because you know that it is the right thing to do. To William, ambitious instruction is about going that extra mile, even when you know that there is no incentive to

because that is how you, "produce kids who are functioning at a deeper level and who have a deeper understanding." To William, this begins with giving students *cognitively demanding* tasks which require students to grapple with *problem solving* while having to engage in *explanation and justification* of their reasoning. Note that the terminology italicized corresponds to dimensions of ambitious mathematics instruction. Thus, the claim can be made that William expresses the most emphasis on tasks selection and discourse when discussing the course purpose during his interview, however, this emphasis does not necessarily emerge from observational data unpacked in Assertions 1 and 2.

Case 2: Brittany. As discussed in Assertion 2, Brittany describes having been in the field long enough to see a shift in how elementary mathematics methods courses have been taught. In her first interview, she mentioned how when she first arrived at Robins, she focused more on MCK than PCK in her methods courses. She commented that, "they were more traditional." However, because of revised program requirements in content courses and the additional elementary mathematics methods course (went from one to two), she now feels as if she has more time to focus on PCK. This dilemma between time spent on MCK and PCK was further elaborated upon when Brittany was asked what she wanted her TCs to learn and know how to enact from her methods courses as seen in the following excerpt.

> Mainly, I want them to, and I hate to say, it's not that I focus on algorithms, but unfortunately, because of standardized testing, I have been forced to really address algorithms. But I want them to [first] understand what's going on when they solve traditional algorithms or algorithmic, you know, when they use an algorithmic procedure. I want them to understand what's going on, and to also know that there are different procedures or algorithms that can be used to solve the same problem. And it's really

> difficult because they already know the traditional way. And I mean, to me, that's one of the biggest challenges that I have, getting them to set that aside and focus on the different methods.

In the previous passage, we can see Brittany's emphasis on MCK, but we can also see how she wants the TCs to develop conceptual understandings that can be fostered in their own classrooms, with their own elementary students. This ties back to Assertion 1 and the unified focus on creating OTL that unpack what it means to teach for conceptual understanding. In response to the question about the purpose of her method courses explicitly, Brittany once again talked about understanding the mathematics, but she then continued to elaborate on how her secondary purpose involves helping her TCs learn how to seek out resources especially when they lack confidence in their understanding of the content.

Brittany's focus on seeking out resources such as practitioner-based journal articles relates to her emphasis on planning. Brittany believes that one develops ambitious instruction (informed by her own understandings of terminology) through purposeful planning.

> ... you can accomplish ambitious instruction by being well planned. [The participant was questioned about what is important to plan for] … you want to start with a measurable objective. And I have to help my students to understand what that even means… You have to plan for that and it has to be important to you, to plan it because it's too easy otherwise. To me, it is really easy to be an elementary teacher if you don't do a good job, you've got the text books that do it all for you, but if you want to be a good teacher, you've got to spend the time planning.

Brittany's comments and actions reveal her perspectives surrounding the purpose of her methods courses, specifically, the development of MCK, the awareness of available teacher resources, and

how to plan for ambitious instruction. Brittany acknowledged that ambitious instruction, such as that incorporating project-based learning, takes time, possibly years for novice teachers to develop.

Reflecting upon the dimensions of ambitious mathematics instruction, Brittany's goals for the courses focus primarily on coherence inclusive of engaging in thoughtful planning within the *structure of a lesson* as well as adhering to *mathematical accuracy*. Brittany's expressed emphasis on planning appears in Assertion 1 based upon her focus on facilitating the planning process for the peer-teaching episodes, and her emphasis on MCK was unpacked in Assertion 2, especially in the excerpt for which we see her deriving geometric formulas.

Case 3: Megan. Megan felt like part of the purpose of her elementary mathematics methods course was to address the TCs' beliefs about mathematics. One of her course assignments included a mathematics autobiography to have the TCs confront their own beliefs as it related to their experiences with mathematics education. She stated, "a lot of the pre-service teachers, have negative views of mathematics in general and negative views of the way they've been taught mathematics." Thus, a goal of her course included helping the TCs develop a more informed understanding of different methods and strategies for helping all learners see themselves as "doers" of mathematics.

Additionally, some of the instructional strategies that Megan stressed as being important for the purposes of the course align directly with the dimensions of M-Scan for ambitious mathematics instruction. Megan's account of the purpose of her course was focused on what she did in her own instruction and the assignments given to the TCs to provide OTL.

I talk about first off what are effective mathematical questions? What do I mean by that? I go by Boaler and Brodie's framework (2004), which is talking about what are the

> different mathematical questions that we have to ask. Yes. Then we talk about multiple representations. This is one that I felt like a lot of my students didn't get to see, so they have to first off ask multiple questions. They have to actually bring in multiple representations whenever they're teaching the concept. They need to think about the level of cognitive demand, and make sure it's a high level even if it's Smith and Steins (1998) level of cognitive demand framework. Either it's doing mathematics or procedures with connections. Either one was fine, I just wanted them to be able to see what that looked like, and then have to make those mathematical links. Mathematical links, I am kind of referring to the Boaler and Brodie connection of what is linked to mathematical concepts.

This excerpt illustrates that Megan's expressed course purpose aligns with the instructional strategies witnessed during classroom observations and unpacked in Assertions 1 and 2. For instance, Megan's instruction focused heavily on: a) the development of various questioning techniques as it relates to fostering classroom *discourse* and the *presence of student explanation and justification*, b) the presence of *multiple representations* inclusive of *mathematical tools*, and c) the *selection of cognitively demanding tasks*. Figure 5 features TCs' group work addressing such dimensions. Also, as seen in Assertion 2, Megan often grounded her OTLs for TCs in research, which appears within her interview excerpt through her description of Boaler and Brodie's (2004) framework and Smith and Stein's (1998) framework. Although Megan did not talk about Cognitively Guided Instruction (CGI) in her interviews explicitly, observational data revealed that Megan did place considerable importance on CGI which makes sense provided her emphasis on question types, cognitive demand, and multiple representations.

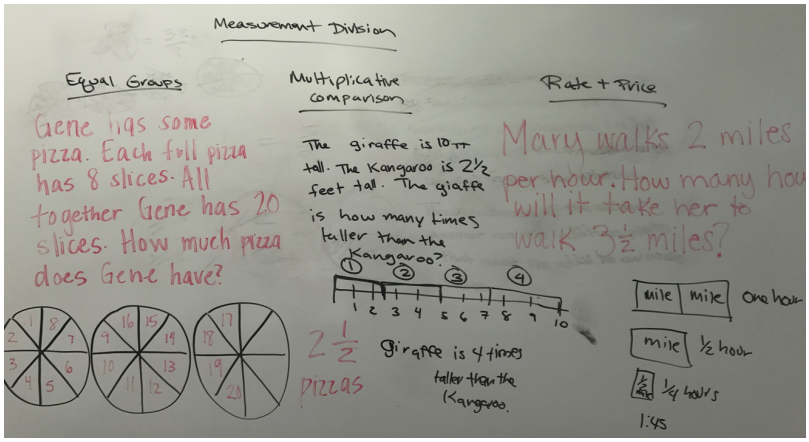

Figure 5: Teacher Candidate Work Samples in Megan's Course

Table 1 has been included to further illustrate the dimensions of ambitious instruction that each instructor expressed when explicitly asked about course purpose. The table also indicates that through various means, all of the instructors address all indicators of ambitious instruction.

Table 1: Elementary Math Method Instructors' Course Purpose within the Dimensions of Ambitious Instruction

Mathematics-Scan Dimensions	William's Emphasis	Brittany's Emphasis	Megan's Emphasis
Task Selection:			
1) Cognitive Demand	p/m/o	m/o	p/m/o
2) Problem Solving	p/m/o	m/o	m/o
3) Connections and Applications	m/o	m/o	m/o
Representations:			
4) Use of Representations	m/o	m/o	p/m/o
5) Use of Mathematical Tools	m/o	m/o	p/m/o
Discourse:			
6) Mathematical Discourse Community	p/m/o	m/o	p/m/o
7) Explanation and Justification	p/m/o	m/o	p/m/o
Coherence:			
8) Structure of Lesson	m/o	p/m/o	m/o
9) Mathematical Accuracy	m/o	p/m/o	m/o
Legend: Specified as course purpose: p Mentioned in interviews: m Observed in classroom instruction: o			

Limitations

Based upon 20 hours of observation, I believe that I observed "normal" instruction for each instructor. The instructors also confirmed that I observed normal instruction. However, it is a possibility that the instructors engaged in activities that they thought that I wanted to see. On another note, the context of this study, and how it is nested within a longitudinal study, may have impacted the nature of the data collected. During the timeframe that I was in the process of performing observations, one of the PIs on the larger study came to Robins University in late September and gave a brief presentation on some of the larger study's initial findings as it related to the institution's first-year teacher survey data. This presentation caused skepticism with my participants as they questioned the overall purpose of the longitudinal study and how data were going to be used. Thus, this presentation alone may have impacted instruction delivery and research participation.

Discussion & Implications

In summary, the first two research questions align directly with Assertions 1 and 2. In Assertion 1, I have unpacked the similarities identified across the three elementary mathematics methods instructors' instructional strategies, examining both *what* TCs have an OTL as well as *how* they are provided with OTL. Specifically, the assertion focuses on teaching for conceptual understanding and combating mathematical misconceptions (*what* they have the OTL) (Karp, Bush, & Dougherty, 2014) for which TCs most often experience OTL through representations and approximations (*how* they have the OTL) (Grossman et al., 2009). In Assertion 2, I have examined each case to unpack the differences identified in instructional strategies and OTL for TCs. In Case 1, William focuses more (than the other instructors) on OTL that address the NCTM process standards (what) (NCTM, 2000) through reflection and feedback (how). In Case

2, Brittany creates OTL that place more emphasis on MCK (what), whereas both William and Megan think more holistically about MKT (Ball, Thames, & Phelps, 2008). Additionally, Brittany created OLT through hands-on activities, technological applications, and interdisciplinary instructional strategies (how). In Case 3, Megan creates OTL around research in the field (what), often having TCs engage in group work linking research and practice while focusing on the presence of multiple mathematical representations (how) (Berry et al., 2017). In both Assertions 1 and 2, beliefs (Phillips, 2003) about effective mathematics teaching practices were demonstrated in the actions of the instructors, resulting in various learning opportunities for TCs. As the researcher, I want to be clear that I am not claiming that any of the instructors were engaging in preferential OTL, but rather, that different OTL were present for TCs.

Assertion 3 assists us in answering the third research question, addressing how the different methods instructors perceive the purpose of the elementary mathematics method courses. Within this assertion, I have analyzed each case separately and attempted to demonstrate how each method instructors' perception of the purpose of the methods courses aligns with the dimensions of ambitious mathematics instruction as indicated by M-Scan (Walkowiak, Adams, & Berry, 2019), and in doing so, have indicated differences across the three cases. While Assertions 1 and 2 draw heavily upon observation data and what the instructors were doing in their classrooms, Assertion 3 unpacks how the methods instructors primarily expressed their course purpose (via interview data) and how that compares to what they were actually seen doing in Assertions 1 and 2. It is important to acknowledge that not all of the instructors' perceptions of course purpose were supported in their actions; thus, they would not be considered psychologically strong beliefs as defined in this study (Phillips, 2003).

This study may prove to be influential as we continue to reflect upon the longitudinal study. However, as it directly relates to the purpose of this study, the findings add to literature (e.g., Clift & Brady, 2005; Cavanna et al., 2017) that discusses the range of teaching practices in elementary mathematics methods courses and OTL for TCs. For example, this study provides insight into the content covered within these methods courses and the pedagogies of practice (Grossman et al., 2009) being incorporated into the instructional strategies. Furthermore, this study, like others (e.g., Koedel et al., 2015), continues a much larger conversation about an overarching critique in our field regarding how OTL may vary across methods courses, and so, TCs who attend the same teacher education program may have very different experiences and OTL. In particular, this study highlights how differences in OTL seems to be linked to individual instructor's belief surrounding effective mathematics instruction. This is pivotal as we reflect upon the development of ambitious instruction and deserves further attention in mathematics education research especially when we contemplate the ways in which generalizations are sometimes made at the program level when unpacking teacher preparation.

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Appendix

First Interview Protocol

1. Tell me a little about your educational background and experiences in teaching and teacher education. (What is your degree in? How long have you been teaching the methods course? Do you have elementary school teaching experience? Please describe (length, location, grade level, subject if departmentalized)
2. Describe the major objectives of the methods course as you see them. (Note: if there is more than one required methods course in mathematics or ELA at their university, ask them to indicate which course they teach and when in the program it is offered; Probe for whether they primarily focus on helping candidates develop knowledge, instructional strategies, skills, practices, approaches;
3. How would you characterize the overall approach to teaching that you seek to develop among the teacher candidates through the course? (Probe for their beliefs/philosophy regarding purposes of teacher education; Probe for their perception of any differences between how the program expects them to teach the course and their approach to teaching the course)
4. What major instructional strategies do you want teacher candidates to learn and know how to enact? Why do you focus on these strategies?
5. How do you engage teacher candidates in learning these strategies? (Note: If they have taught the course multiple times, probe for their most recent experience teaching the course; Note: Ask them to send us/review their course syllabus and major assignments prior to the interview)
    a. What kinds of activities do you use to help them learn about these strategies?
    b. What kinds of activities do you use to help teacher candidates build their skill in enacting these strategies?
    c. How do you assess the teacher candidates' knowledge and skills enacting these strategies?
6. What are the major assignments and how do they relate to the major objectives? (Ask participant to take you through the assignments to explain the following:)
    a. Major goals and objectives
    b. How teacher candidates are prepared to complete the assignments
    c. How assignments are assessed
    d. How assignments are related to student teaching or clinical practice.
    e. How assignments relate to capstone project or other program-wide assessments?
7. How does this course fit into the goals and guiding principles of the larger teacher education program? (Probe for connection to other courses, field experiences)
8. How would you characterize the teacher candidates' knowledge of mathematics (ELA)? For example, what is the range of mathematical content knowledge? What types of backgrounds in mathematics do students typically have? Do you address content knowledge in your course? Please describe.
9. What kinds of interactions do you have with cooperating teachers? With university supervisors? (Probe for frequency, types, and content of interactions?
10. Do you typically visit your methods students during practicum or student teaching placements? (Probe: If they do visit their methods students in schools, ask what they focus on during these visits)

Second Interview Protocol

Approximations

1. How do you support students in preparation for teaching episodes? (assumption based on observations)
2. How do the teaching episodes influence your instruction?
    a. Probe for impromptu teaching

Representations

3. Please talk about the various ways in which you model teaching for your students.

External Context- Surrounding Teacher Preparation

4. How do you select classroom activities? What influences your selection of these activities?
    a. Probe for depth versus breadth
    b. Probe for focus on standards versus time for more hands-on-tasks on topic

Addressing Mathematical Misconceptions

5. What is the relationship between misconceptions and mathematics content knowledge (MCK)?

Classroom Environment

6. How would you describe your rapport with your students? How does this manifest in classroom management?

What should be done moving forward?

7. In your opinion, what should be done to help teacher candidates moving forward?
    a. Probe for classroom management and curriculum implementation
    b. How do we have students buy-into implementation of non-traditional forms of teaching?

Ambitious Instruction

8. How would you define ambitious instruction in your own words?
    a. How do you implement this in your class?

Class Purpose

9. What is the purpose of the class?
    a. What do you want students to walk away with at the end of the semester?

Manuscript Three

District Certified Culturally Responsive Teachers and Their Elementary Mathematics Teaching Practices: A Multi-Case Study

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Abstract

This multi-case study examines how three elementary teachers, all certified by their school district in culturally responsive teaching (CRT) through professional development opportunities, implement mathematics teaching practices that support CRT. Furthermore, this study examines the CRT certification process in the focal district and the structures that supported the teachers in their enactment of CRT. In this district, the achievement gap for historically marginalized youth is a major concern, and CRT has been identified by division leaders as one means for addressing the gap on state standardized test scores. Thus, the desired outcome for teachers, principals, counselors, and division leaders is to increase student achievement based upon application of CRT. Data were collected via interviews, questionnaires, observations, teacher journals, and other reportable data. The teachers' CRT practices in mathematics fell into four large quadrants aligning with the work of Hammond's (2015) *Ready for Rigor* framework. This study is significant because its findings expand upon the literature and provide us with a more informed understanding of what CRT can look like in elementary mathematics classrooms with teachers who have been certified in CRT from a district developed and applied certification model.

The achievement of historically marginalized students has been an ongoing concern for stakeholders. Gay (2010) stated, “The achievement of students of color continues to be disproportionately low at all levels of education, and the need to change these dismal conditions is even more pressing” (p. xxvii). While addressing student achievement in mathematics education, Bonner (2014) emphasized how data from the National Center for Education Statistics (NCES, 2009) indicated that from 1990 to 2007 there was, “little progress in closing the persistent mathematics achievement gaps between certain groups” (p. 377). More recently, the National Assessment of Educational Progress (NAEP, 2017) reported that though there were not significant changes in racial and ethnic disparities from the previous years, the scores of White students remain higher on average than those of their Black and Latinx peers, indicating that while the achievement gap is smaller than it was in 1990 (the first assessment year) disparities are still prevalent. Although there are numerous reasons why such achievement gaps persist between students of color and their White counterparts in mathematics, including but not limited to, tracking/leveling, access to resources, institutional racism, and stereotype threat, research has shown that the achievement of historically marginalized youth is likely to increase when learners have positive mathematical identities (e.g., Borman & Overman, 2004) and cultural identities (e.g., Moll, Amanti, Neff, & González, 1992). Teachers play a significant role in forming student perceptions and fostering the development of such identities (Schoen, Cebulla, Finn, & Fi, 2003).

Thus, Gay (2010) stated, “Culturally responsive teaching (CRT) is a means for unleashing the higher learning potentials of ethnically diverse students by simultaneously cultivating their academic and psychosocial abilities” (p. 21). Though the theoretical framework for CRT has informed the educational community for quite some time, scholars (e.g., Hammond, 2015) continue to discuss the challenges of how to operationalize CRT in practice. Mathematics

education in particular has produced limited research examining the teaching practices of culturally responsive teachers in pre-kindergarten through 12th grade (preK-12) (Thomas & Berry, 2019). The purpose of this proposed multi-case study is to examine the CRT practices of three elementary mathematics teachers who have been locally recognized and certified in CRT by their school district. Furthermore, the intent is to examine the CRT certification process in the focal district and the structures that supported the teachers in their enactment of CRT with historically underserved students, in their efforts to address the achievement gap. Though there is variability in how to define an achievement gap (e.g., test scores, course enrollment patterns, cognitively demanding learning opportunities, etc.), this study is primarily utilizing the terminology to emphasize the gap in standardized test scores, based upon how the focal district is operationalizing the construct. Language surrounding an achievement gap is used to describe the context within the district; however, this study is not "gap gazing" (Gutiérrez & Dixon-Román, 2011, pp. 21-34).

Culturally Responsive Teaching

Theory of Culturally Responsive Teaching

Geneva Gay introduced a CRT framework for "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. It teaches *to and through* the strengths of these students." (Gay, 2010, p. 31). Gay (2010) outlines six tenets of CRT:

1. *Validating and Affirming*: Teachers see their students' cultural differences as assets. They not only value the students' individual cultural heritages, but they also use such knowledge to establish learning communities, inform teaching practices, and develop partnerships between school and home.

2. *Comprehensive*: Teaches are expected to "teach the whole child" for which students develop skills while maintaining their cultural identities (p. 32). There is an emphasis on maintaining high expectations both for the individual and for the group.
3. *Multidimensional*: Teachers have to attend to, "curriculum content, learning context, classroom climate, student-teacher relationships, instructional techniques, classroom management, and performance assessments." (p. 33).
4. *Empowering*: "Teachers must show students that they expect them to succeed and commit themselves to making success happen" (p. 34).
5. *Transformative*: Students have to learn how to, "analyze the effects of inequities… and become change agents committed to promoting greater equality, justice, and power balances among ethnic groups" (p. 37).
6. *Emancipatory*: Students are liberated from the single story of the truth and enabled to see from multiple cultural perspectives.

Gay (2010) cites Gloria Ladson-Billings' framework on culturally relevant pedagogy (CRP) as foundational to the framing of CRT.

Ladson-Billings (1994) defined CRP as, "a pedagogy that empowers students intellectually, socially, emotionally, and politically by using social referents to impart knowledge, skills, and attitudes" (p. 17-18). CRP is a "pedagogy of opposition, not unlike critical pedagogy but specifically committed to collective, not merely individual empowerment" for which "the primary aim of CRP is to assist in the development of 'relevant black personality' that allows African American students to choose academic excellence yet still identify with African and African American culture" (Ladson-Billings, 1995, p. 160; Ladson-Billings, 1994, p. 17). Teachers must first develop sociocultural consciousness and caring, prior to engaging in the

tenets of CRP that include: 1) providing educational self-determination (high expectations); 2) honoring and respecting the students' home culture (cultural competency), and 3) helping students understand the world as it is and equipping them to change it for the better (critical consciousness).

It is important to emphasize that the line between these two frameworks (CRP and CRT) often becomes blurred in the literature as researchers use the language interchangeably. Aronson and Laughter (2016) claim that CRT affects competence and practice whereas CRP affects attitude and disposition. Gay (2010) stated, "Although called by many different names, including *culturally relevant*, … and *responsive*, the ideas about why it is important to make classroom instruction more consistent with cultural orientations of ethnically diverse students, and how it can be done, are virtually identical" (p. 31). Additionally, in some cases, authors (e.g., Bonner, 2014) who label their work as culturally responsive stated that that their work was, "largely guided (theoretically and practically) by the work of Gloria Ladson-Billings and others who have developed foundational ideas of CRT in the literature" (Bonner, 2014, p. 380). This makes it challenging to distinguish between CRT and CRP in more recent work.

It should also be acknowledged that there are numerous works in the literature (e.g., Aronson & Laughter, 2016) which attempt to combine the two frameworks (CRT and CRP) and examine *culturally responsive education*. Furthermore, some scholars (e.g., Hammond, 2015) have recently introduced frameworks which claim to make CRT (combining tenets of CRT and CRP) more operationalizable in non-content-specific ways.

Provided that the objective of this study is to work with teachers who have been certified by their school district in CRT, for which the professional development (PD) for the certification draws upon the work of Ladson-Billings, Gay, and other researchers who cite both as influential

in the development of a CRT framework, I have included Ladson-Billings' framework on CRP as foundational within the CRT framework because of how it has been operationalized with the study's participants. This study is grounded in the theoretical framework for CRT both in theory and practice.

Operationalizing Culturally Responsive Teaching

Hammond (2015) claims that her work addresses a gap in the literature by, making explicit, "the natural intersection between so called brain-based-learning and CRT" (p. 4). Hammond (2015) states that, "cognition and higher order thinking have always been at the center of CRT [citing both Gay's and Ladson-Billings' work] … [but], neuroscience offers a way to understand and organize our CRT practice" (p. 4). Furthermore, Hammond (2015) discloses that in her own experiences, teachers have been challenged with how to operationalize CRT and turn it into practice, and this is where she sees her work contributing to the literature. In her *Ready for Rigor Framework,* Hammond (2015) examines what she calls the four practice areas of CRT including: awareness, learning partnerships, information processing, and community of learners and learning environment, as seen in Figure 1. Although there are numerous terminologies within the four quadrants of this framework that could be unpacked, in what follows I have focused on those that are most relevant to the proposed study and/or most personalized (not as commonly discussed in the field).

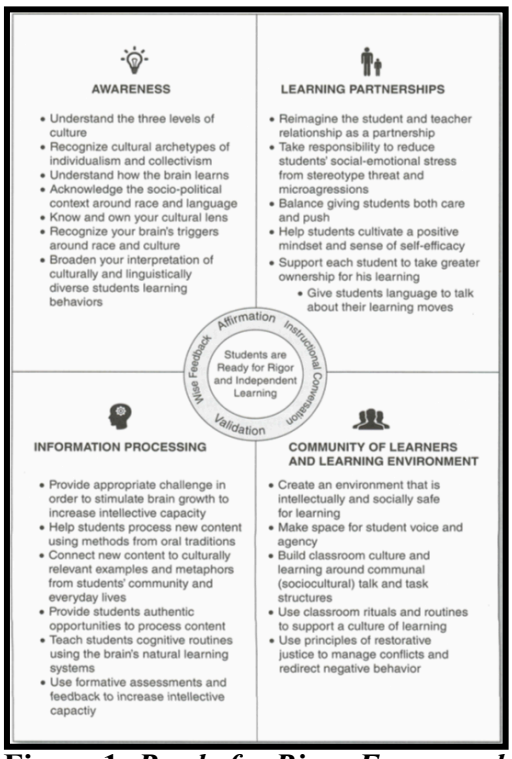

Figure 1: ***Ready for Rigor Framework***
(Hammond, 2015, p. 17)

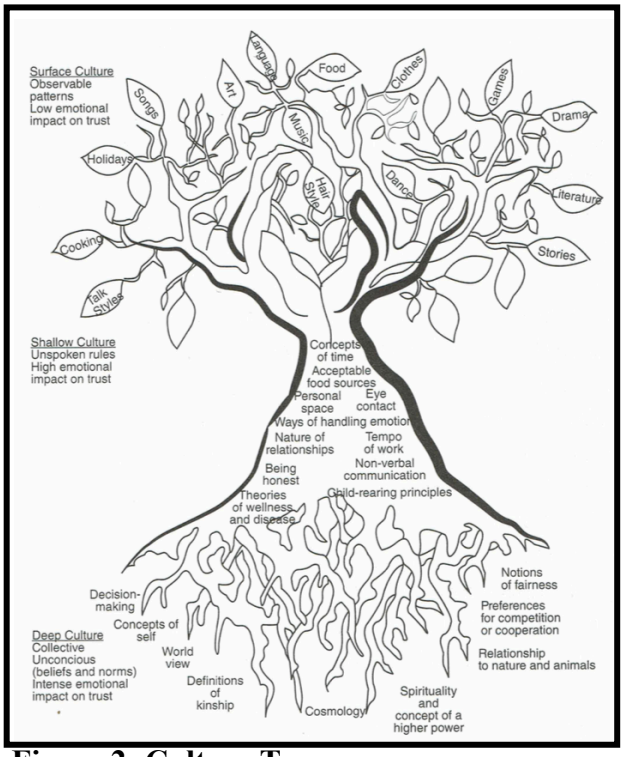

Figure 2: Culture Tree
(Hammond, 2015, p. 24)

Awareness is located in Hammond's (2015) first quadrant (upper left). Hammond (2015) states that this is the place to start as teachers reflect upon their intentions and examine their implicit biases. She talks extensively about how CRT is a mindset, not a set of strategies. Awareness includes *widening your interpretation aperture* and *identifying your triggers*. Widening our interpretation aperture means that teachers, "let in more alternative explanations for students' learning behaviors and social interactions that look different from [their] own" (Hammond, 2015, p. 59). Identifying triggers means that teachers become aware of situations (often brought on by cross-cultural miscommunications) that cause them to be emotional and/or reactive, and they learn how to manage such emotions. This first quadrant also addresses the need to understand the three types of cultures and learners' funds of knowledge. Figure 2, models the three levels of culture in this framework. It is important to recognize that Hammond (2015) claims that CRT must focus on deep culture or the roots of the tree; she argues that by

focusing on deep culture, a teacher can attend to universal patterns or similar *cultural archetypes* in a class that may be diverse and inclusive of learners of many different cultures.

In Hammond's (2015) third quadrant (bottom left), she focuses on information processing and building intellective capacity. Specifically, she emphasizes four macro level instructional strategies including: ignite (getting the brain's attention), chunk (making the information digestible), chew (actively processing new material), and review (applying the learning), and discusses how CRT techniques can be embedded within these strategies. Hammond (2015) also discusses the need for students to engage in cognitive routines that incorporate the sequencing of information in specified structures (i.e. similarities and differences, whole-to-part, relationships, and perspectives).

It should be acknowledged that Hammond's (2015) work places a strong emphasis on embracing CRT to close the achievement gap, which has made it an influential text in the certification program in William County (pseudonym), the focal district for this study. However, Hammond (2015) defines the achievement gap in terms of the identified differences in analytic readiness and effective information processing of learners based upon their prior learning opportunities. Thus, she argues for rigorous teaching to build brainpower focused on high order thinking, creative problem solving, and analytic reading and writing skills as called for by standards-based teaching practices. So, although she talks about state standards, she is not advocating for raising scores on standardized tests. Nonetheless, Hammond stated, "You cannot call yourself a 'culturally responsive' educator if your purpose is to raise test scores rather than to liberate young people's spirits and ignite their intellectual curiosity (Twitter, 28 August, 2019).

Culturally Responsive Mathematics Teaching in Practice

Although there have been numerous works (e.g., Ladson-Billings, 1994; Nieto, 2010; Siddle-Walker, 2000) in the field of education that have informed our understanding of teaching students from diverse backgrounds, the implementation in mathematics has been limited (Bonner, 2014). Bonner offers three reasons for why this might be the case, including: 1) the majority of the works are specific to one population such as African American learners (e.g., Ladson-Billings, 1994); 2) literature has a broad focus on content and practice, making it non-mathematics-specific (e.g., Gay, 2010); 3) and, the works remain largely theoretical (e.g., Greer et al., 2009).

Based upon extensive research on Gloria Jean Merriex, a mathematics teacher, Bonner (2011) inductively constructed a theory for culturally responsive mathematics teaching (CRMT). In the CRMT framework, culturally responsive teachers have to first examine their own assumptions and truly believe in their students. As indicated in Figure 3, there are four cornerstones of instruction in CRMT including: relationships and trust, communication, knowledge, and reflection and revision. These cornerstones are not mutually exclusive but are always interacting with one another. Knowledge includes mathematics content knowledge (MCK), pedagogical content knowledge (PCK), mathematics knowledge for teaching (MKT) and knowledge of learners. This is the cornerstone that is unique to CRMT, and which makes it content specific. At the center of the figure, we can see how students are constantly involved in a cycle of pedagogy and discipline including that of a warm demander.

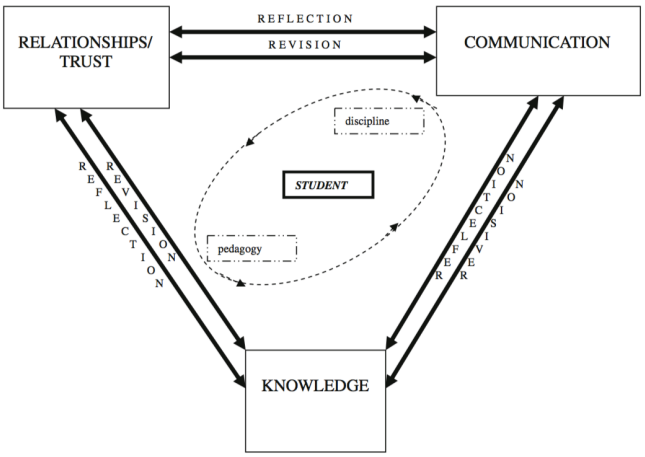

Figure 3: CRMT Framework
(Bonner & Adams, 2012, p. 29)

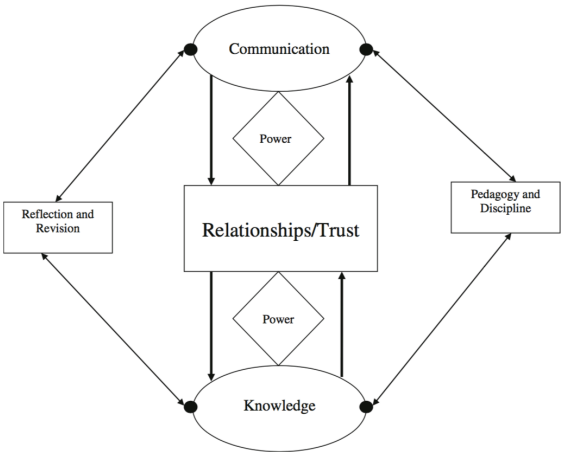

Figure 4: Revised CRMT Framework
(Bonner, 2014, p. 388)

Bonner (2011) states that "only data collected in Gloria's classroom was used in analysis… [but] subsequent interviews with other persons… have corroborated these findings" (p. 35). In a later work, Bonner (2014) revised the framework following a study with three participants and added *power* to the model for CRMT, as seen in Figure 4. *Power* references to the "fluidity of power in the classroom, and the "shared power with students" (p. 393). Although Bonner's work (2011, 2014; Bonner & Adams, 2012) has contributed extensively to generalizing CRMT in practice, it must be acknowledged that there is a dearth of research focused on mathematics teaching and learning.

Thomas and Berry's (2019) qualitative metasynthesis focuses upon peer-reviewed research articles that reported on studies grounded in CRP and/or CRT, preK-12 in mathematics education in the United States. As of February 2016, there were only 12 articles (including Bonner and Adams, (2012) and Bonner (2014)) meeting the search criteria of high rigor as determined by the appraisal rubric in Thunder and Berry (2016). Thomas and Berry (2019) synthesized and interpreted the findings from these studies to understand how researchers interpret mathematics teaching practices that support CRP and CRT. The five findings from that

study include: caring, context, cultural competency, high expectations, and mathematics instruction.

The implications of the metasynthesis indicate that we still have a very limited understanding of what CRT and CRP look like in mathematics classrooms. In particular, it is unclear whether developing critical consciousness is emphasized in mathematics classrooms. Furthermore, the last finding, "mathematics instruction" suggests that there is a strong relationship between the enactment of CRT in mathematics and *standards-based teaching practices* (NCTM, 2000; Walkowiak, Berry, Pinter, & Jacobson, 2018). However, more work needs to be done to examine what mathematics teaching practice, including use of mathematics representations (Berry et al., 2017) and discourse, are most interconnected with supporting CRT. Additionally, "It is not clear in what ways context and support within schools [and district] communities are central elements in CRP and CRT" (Thomas & Berry, 2019, p. 29).

Purpose of study. Provided that we still have a very limited understanding of what CRT looks like in practice, specifically in mathematics education, this study will expand upon the literature by linking research and practice (Cai et al., 2017). Furthermore, by focusing on CRT in elementary mathematics classrooms, with teachers who have been certified in CRT in a focal district, this study addresses a gap in the literature, since most teachers participating in research have been self-identified or researcher-identified rather than certified by county policies and supported by county structures in becoming culturally responsive.

Research Questions

The following research questions guide this study:

1) How do teachers in William County become fully certified in CRT, and what structures support teachers in their enactment in the focal district?

2) How do three elementary teachers, who have been certified in CRT, implement mathematics teaching practices? How does the mathematics instruction support CRT?

Methods

Researcher Positionality

As a former mathematics teacher, I am invested in work that focuses on teaching practices in preK-12 that make mathematics more accessible, equitable, and empowering for learners. For an extended period of time, my advisor and I worked on a qualitative metasynthesis, discussed in the literature review, that synthesized and interpreted teaching practices that support CRP and CRT in mathematics education. As I have become more familiar with the research, I have not only realized how limited the literature is in the field, but also, how imperative it is that we take steps to link research and practice to operationalize CRT in mathematics classrooms. Additionally, while I am not a proponent of "gap gazing" (Gutiérrez & Dixon-Román, 2011, pp. 21-34) provided that it does not adequately represent the inequities experienced by children in mathematics, I have utilized such language to portray the purposes of the certification program and the districts' desired outcomes.

Site: William County

William County is located in a southeastern state; it is particularly known for its diverse student population inclusive of over 90 spoken languages. According to the state's department of education, there are approximately 14,000 students enrolled in elementary schools in William County, preK-5. Student demographics for preK-5 include: Native American (<1%), Asian (5%), Black (11%), Hispanic (13%), Native Hawaiian & Pacific Islander (<1%), Non-Hispanic/bi-racial/multi-racial (6%), and White (65%). Additional demographic information for this population indicated that 20% are disadvantaged, 10% are English Language Learners, 1% are

homeless, and 13% are disabled (please note that this is the descriptive language used by the department of education, not language that I would use myself to describe populations of students). Despite such diversity, the achievement of historically marginalized youth on standardized tests has been a major concern for the district due to state-level politics and accreditation standards.

In an effort to close the achievement gap, in William County, leaders at the district level engaged in more than nine years of research to create a CRT certification program for preK-12 teachers, administrators, and counselors. Dr. Wayne (pseudonym), the Assistant Superintendent for School Community Empowerment, stated, "we have created a home-grown model [for certification] but it's research-based, [and] it's evidence based." In Spring 2016, four teachers represented the inaugural class of district certified culturally responsive teachers in William County. As of June 2018, that number increased to 17 certified individuals (teachers, administrators, councilors, etc.) across the county. In the summer of 2019, 23 more individuals received certification, many from Willow Elementary School (pseudonym). Dr. Wayne, has stated that they currently do not have any secondary mathematics teachers certified.

As previously noted, to date, 40 individuals have received full certification. Of the certified teachers, who are still teaching within the county, the majority are working at the elementary level. For the purpose of this study, I have engaged in purposeful, criteria sampling to secure the consent of three elementary teachers who currently teach mathematics and who are fully certified in CRT by the district. I was also purposeful in attempting to secure the consent of teachers across different grades.

Sample

The three teachers in this multi-case study are Skylar, Elizabeth, and Clay (pseudonyms). All three teachers were part of the most recent cohort to receive certification in Spring 2019 and are actively engaged in district structures to support CRT enactment.

Skylar. Skylar is a pre-kindergarten teacher at River Elementary (pseudonym). She is a Black woman in her mid-30s, and she has been teaching for six years. Skylar identifies with her lineage of strong, independent, Black women, and being a native of the geographic region of the focal district.

As a pre-kindergarten teacher, Skylar has a full-time aide in the classroom who is a White woman of German descent in her late-40s. There are 18 students in her classroom including: 11 Latinx, 5 African American, and two of Middle Eastern descent. One of the African American students is biracial, but her mother who is Black, indicates her daughter's ethnicity as African American, not White. Additionally, 50% of the class is Spanish speaking. There are 11 boys and 7 girls, and Skylar indicated that many of the students come from "low income homes."

Elizabeth. Elizabeth is a third-grade mathematics teacher at River Elementary. She is a Black woman in her late-20s. She was recognized by the district as being a distinguished teacher with honors during 2018-2019. This year is her fifth-year teaching.

Elizabeth is teaching in a multi-age classroom of second and third-graders (her co-teacher is micro-certified in CRT; micro-certification is further examined in the findings), but she only has the third-graders for mathematics. Elizabeth described the students in her class by saying that nine are Black, one is White, two are multi-racial, one is Asian, and seven are Latinx. Further, eight of the students receive English as a Second Language (ESL) services and one student receives special education services. She was very intentional about noting that none of the

students were identified for the gifted program, and she stated that nearly 50% of the students are of low socioeconomic status, receiving free and reduced lunch.

Clay. Clay is a fourth-grade teacher at Willow Elementary. He is a White man in his late-40s who identifies strongly with being Jewish. Additionally, he is in his 11th year teaching. It should also be mentioned that in the 2017-2018 school year, Clay participated in micro-certification for CRT prior to going through the full PD for certification the following year.

Currently, Clay is part of a Spanish Immersion program at Willow, but he does not have a co-teacher, and so, he has the flexibility to teach mathematics in English (given that he is responsible for planning all content). During the time of observations, Clay had 20 students, 13 of whom are Latinx and seven are White. The 13 Latinx students all come from homes of low-socio-economic status. Further, three of the students have individualized education plans and 10 of the students receive ESOL services.

To incorporate multiple perspectives, I will also draw upon the voices and the actions of district leaders including Dr. Wayne, and Zach and Tiffany who are equity specialist with the district (the roles of individuals are further discussed in the findings).

Data Gathering Procedures

During 2018-2019 school year, I spent approximately 20 hours in the field talking to district leaders including the equity specialists and attending district level professional development to learn about the certification process in William County. During the summer of 2019, I began working with teachers as part of this multi-case study.

Mapping cultural reference points questionnaire. Hammond (2015) discusses how teachers have to engage in critical reflections of their own cultural identity. Hammond (2015) claims that teachers cannot truly understand how their own culture acts as a lens influencing their

interpretations of socio-political contexts, student behavior, and teaching practices until they have first examined their own cultural reference points (part of Hammond's (2015) first quadrant). Therefore, in order for me to have an informed understanding of the multiple ways in which the teachers are pushing themselves outside of their own cultural boundaries, and making the "familiar strange," I utilized Hammond's (2015) posed questions to have the teachers reflect upon their surface culture, shallow cultural beliefs, and deep cultural values (p. 56) (Appendix A). These questions were distributed to the teachers following the first semi-structured interview (discussed later) and they were collected prior to my first-class observation. These questions are somewhat personal, and so, I believed that it was important to develop a rapport with the teachers prior to asking them to share their reflections with me. The teachers were asked to respond to the questions that they felt comfortable answering, and then, submit the protocol either via e-mail or in person. Skylar requested to talk through the questionnaire with me immediately following the first interview because of time restrictions (on her part). Therefore, her responses were recorded and transcribed.

Teacher journals. A tenet of being a culturally responsive teacher is practicing self-reflection and building awareness (Hammond's quadrant one). Although teachers have to be reflective upfront, one of the key components of CRT examines how teachers react in the moment and how they use those experiences to inform their teaching practices in the future, as seen in Bonner (2011) with revisions and reflections. For this reason, I believe that teacher journals are an effective and informative method to get at how teachers are perceiving their own mathematics instruction and whether it supports CRT. Furthermore, these journals provide me with a glimpse into each teacher's CRT mindset and the events and/or experiences that each teacher ponders when contemplating, "how can [I] show up differently in [my] relationship with

students?" (Hammond, 2015, p. 53). Following each of the observed mathematics lessons for each teacher, I asked that the teachers briefly reflect, (taking approximately 10-15 minutes) using the journal protocol (Appendix B), upon their mathematics lessons. The journal protocol addresses whether teachers perceived that they had to *widen their interpretation aperture*, whether they experienced a *trigger* or an emotional reaction, their own perceptions of how they incorporated CRT into their mathematics instruction, and whether the lesson went as planned or where impromptu adaptations were made in the moment to account for students' needs and/or interests. Journals were collected in person and digitally, based upon convenience for the participants.

Interviews. The purpose of conducting the first round of teacher interviews was to understand the teachers' experiences in the CRT certification program and to examine how the teachers perceive their enactment of CRT in mathematics education. The first interview was semi-structured, using the protocol found in Appendix C, and lasted approximately 30-60 minutes. As previously mentioned, this first interview was important for establishing rapports with the teachers. I conducted a second round of interviews (approximately 30-60 minutes) with all teachers, following observations to further unpack some of the emerging themes and findings, as it pertains to each teacher's CRT practices and to discuss support structures in the district (protocol in Appendix D).

Classroom observations. Classroom observations allow for me to observe what CRT looks like in practice and what factors may be mediating instruction at the classroom level. I am able to observe the actions of the teacher inclusive of both how she gains knowledge about her students and how she uses such knowledge to inform her teaching practices. Additionally, observations allow for me to gain a deeper understanding of the teacher-student interactions that

occur within the classroom and whether those interactions lead to positive learning partnerships and classroom environments. I used an observation protocol (Appendix E) drawing upon tenets of CRT to observe each teacher's mathematics lessons (1.5 hours per day) for two consecutive weeks (the approximate time of a unit). I video recorded each lesson and collected data using double-column fieldnotes. In two months (September and October), I was in Clay's class for 15 hours and both Skylar and Elizabeth's for 16.5 hours each. This was the approximate time of a mathematical curriculum unit within the instruction.

Other reportable events. *Other reportable events* in this study is multifaceted. For example, in my time with teachers, informal, unstructured interviews and conversations arose throughout the semester that also served as points of data collection. And, while performing classroom observations, I collected various forms of artifacts such as assignments, student work samples, and photographs when possible. Additionally, I continued to be involved in community partnerships and to attend division meetings and school-wide equity meetings. Such involvement led toward additional data collection points in these public spaces.

Data Analysis

The information gathered from the mapping of cultural reference points questionnaire served as preliminary data and led toward the development of other methods; particularly, by helping to inform the observations. Reading through the teachers' responses allowed for me to understand the teachers' reference points and more easily identify how the teachers were making adaptations and engaging in CRT. Teacher journal reflections were read, re-read, and compared to the data from the corresponding classroom observations. From this data source, I examined each teacher's awareness, and whether the teacher was acknowledging similar incidences (triggers, strategies, etc.) as myself or whether there were patterns of alignment. Furthermore, I

examined patterns that occurred throughout the semester as documented within these reflections for each teacher and across teachers.

Both rounds of semi-structured interviews with teachers were recorded and transcribed to allow for member checking when necessary. I was purposeful in transferring all fieldnotes into write-ups within 24 hours of the respective classroom observation and wrote analytic memos intermittently to document emerging themes and inferences from transcripts, write-ups, journal reflections, and other reportable data. Dedoose was used to support the coding process, using a combination of inductive and deductive coding. I began by taking an inductive coding approach, but then drew upon deductive coding based upon theory of CRT (Corbin & Strauss, 2015). During later coding, I went back to inductive coding. Data sources were triangulated and re-read and re-coded to document emerging patterns and themes of CRT practices. I compared confirming and disconfirming evidence and continued to adjust my findings until all of the evidence was accounted for. Additionally, provided that I was the sole individual coding, I engaged in peer debriefs and consult with experts in the field about emerging themes and patterns that align with my theoretical frameworks to ensure trustworthiness. A methodological log was kept from 2018-2020 to document all decision points during data collection and analysis.

Findings

District CRT Certification

To become fully certified in William County, individuals must first participate in a three-part workshop series (either as a full day PD or three separate opportunities). The three modules include: 1) recognizing your cultural lens, 2) engaging diverse learners, and 3) ensuring equitable parent participation. Secondly, individuals must attend monthly (from August -May) cohort meetings which range approximately one hour each to unpack readings (e.g., Hammond, 2015)

and to engage in reflective activities in collaboration with their colleagues while focusing on the three characteristics of the CRT certification program. It is also possible to receive micro-certification by only focusing on one characteristic with a separate cohort. The characteristics of the CRT Certification (2015) state that culturally responsive teachers: 1) acknowledge and incorporate the importance of cultural heritage of all students, while reflecting on their own personal cultural influences; 2) provide multi-cultural instruction and differentiation for relevance and rigor; and, 3) build positive learning partnerships with students and families. Lastly, to become certified, individuals must submit a portfolio (including an essay and student data) that 1) demonstrates proficiency in the three characteristics of CRT and 2) shows, "evidence of increased student achievement due to successful application of CRT strategies" (CRT Certification Model, 2015). These portfolios are evaluated in addition to the candidates' oral presentations (often accompanied with PowerPoint slides) at the district Equity Conference each spring.

Based upon my time observing such PD opportunities (found in data collection for other reportable events) it is evident that the modules were developed by division-level leaders (later discussed and illustrated in Figure 5) by drawing upon the work of Gay (2010), Ladson-Billings (1994), Hammond (2015), and other scholars in the field (non-content specific). Further, as part of the certification, teachers are required to read the work of Hammond (2015) for which three of the four quadrants align closely with the county's modules.

Structural supports for becoming culturally responsive. Receiving certification is only part of the initiative when referencing to the structures in place in William County that support individuals in becoming culturally responsive. There are structures in place that are continually influencing the teachers' learning and implementation of CRT. Figure 5 illustrates

the structural hierarchy of support and the county's Equity Model which has been in place for several years.

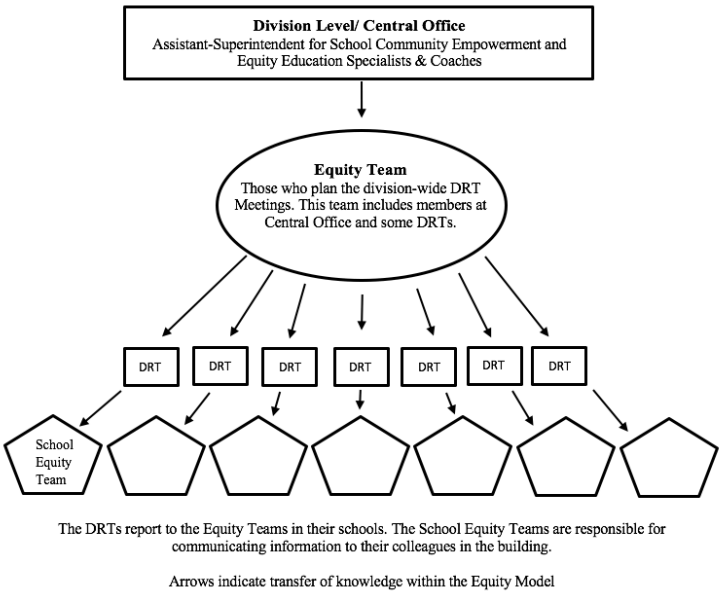

Figure 5: Equity Model

At the top, you have those at the division level in central office including Dr. Wayne and the equity specialists, Zach, Tiffany, and Amy (pseudonyms) with each assigned to specific schools to work with each year. Following the division level is the Equity Team for the county. These people (including those at central office) work together to plan for monthly division wide diversity resource teacher (DRT) meetings. Recently, the Equity Team has made it a priority for all PD to focus on CRT issues and/or concerns, and so, they have started to refer to this level as the CRT Leadership Team. The DRT meetings each month are open to the public but are specifically considered PD for folks who are diversity resources teachers or who are there for the CRT cohort meetings which break-out during the second-half. DRTs represent their schools and support smaller equity teams within their buildings. Up until the 2019-2020 school year, DRTs did not have to have CRT certification. However, now, all DRTs must have full CRT certification or be going through the process. It is also worth noting that the district has

instructional coaches assigned to specific regions; to date, some of these instructional coaches also have CRT certification. This means that in some regions, like that of Willow Elementary, the instructional coaches can also come into classrooms and assist teachers with developing their CRT practices.

It should be noted that in the Fall of the 2019-2020 school year, all of three of the teachers in this study were recruited for leadership positions in this model. Skylar and Clay both serve as DRTs for their schools, and Elizabeth is a member of the CRT Leadership Team.

Culturally Responsive Teaching in the Classroom

During my time working in the classroom with the teachers, it became evident that their conceptions of CRT were highly influenced by the work of Hammond (2015) and the *Ready for Rigor* framework. However, similar to other works surround CRT, some of the components of each quadrant exemplified particular tenets that are more thoroughly captured in other literature (e.g., Gay, 2010; Ladson-Billings, 1994). The findings have been outlined in Figure 6. Note that the quadrants have been reorganized (in numerical order) to mathematically model the coordinate plane and the ways in which the teachers went about building CRT at the beginning of the year (September-October). However, it is important to acknowledge that after the initial phase (of consecutive order), this is very much viewed as a continuous cycle without particular attention to order. These quadrants are not mutually exclusive, nor are the domains within each quadrant. Within the findings, I use excerpts from the three cases to facilitate in examining the teaching practices. Although I have attempted to represent each teacher respectively, there are numerous data points that could be utilized as evidence for each finding. Therefore, I have selected teacher excerpts that seem most appropriate.

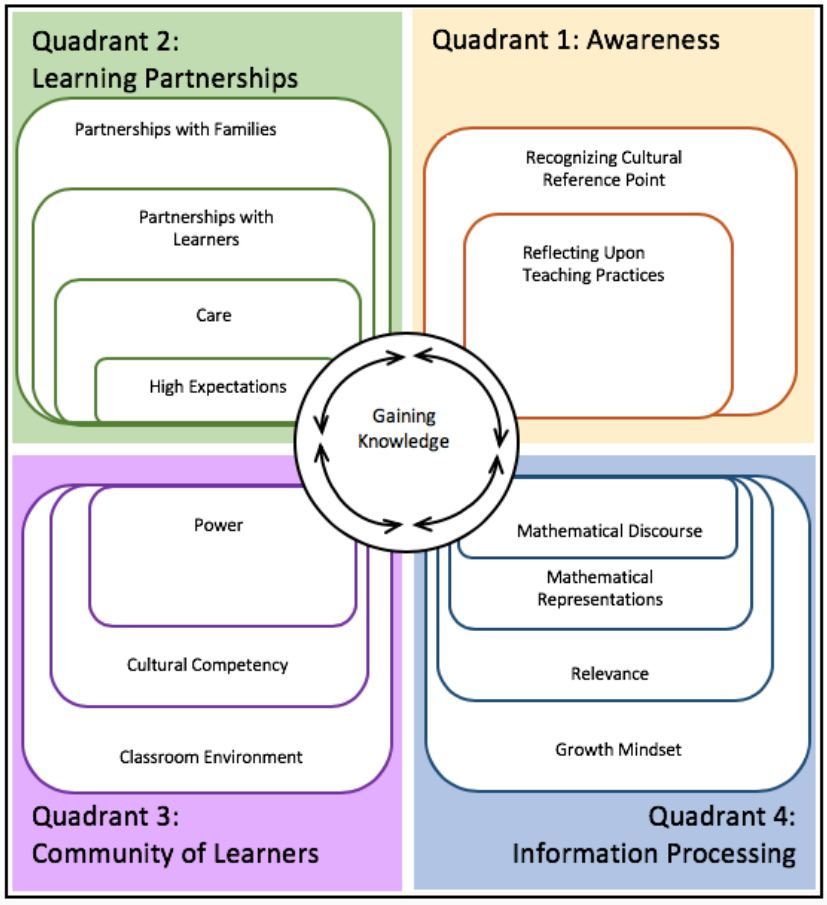

Figure 6: Findings of CRT in Elementary Mathematics Classrooms

Quadrant 1: Awareness. Awareness was demonstrated in the ways in which the teachers gained knowledge of themselves and their own cultural lens, and the ways in which they were reflective in their teaching practices.

Awareness of cultural reference point. During the certification program, *all* of the teachers were required to engage in critical reflection of their own cultural reference points. Some of the reflections were in preparation for their cohort meetings while others became the compilation of their essay for the CRT portfolio. These essays model the ways in which the teachers were gaining awareness of who they are, and in return, beginning to understand how their own cultural experiences influence their perceptions and their teaching practices. Elizabeth

also spoke about how listening to other people present at the CRT Equity Conference made her reflect more deeply upon her own perspectives.

> The ones [presentations] that I found the most fascinating were schools where their population might be majority White because for me, something that I had not considered was this idea that culture is not [just] like a race thing. Especially because I work at River Elementary, which is an extremely diverse school. It's super easy to consider Culturally Responsive Teaching to be about race, when in reality, some of the things that I heard teachers facing with like individualist attitudes with students that are very dependent in math were happening in my room and were things that I was still charting through. (Interview 1, August 2019)

This part of the interview stood out because it illustrates how for Elizabeth, a Black woman, this program made her reflect upon cultural differences that were not rooted in race. Additionally, this excerpt highlights how students who may be very independent in general, lack confidence in their mathematical abilities. Therefore, it was important for Elizabeth to acknowledge that in some cases, that this lack of confidence seems be rooted in stereotypes and stereotype threat that are grounded in other cultural norms (i.e., those based upon gender and/or socio-economic status).

In addition to having access to the teachers' portfolios, the questionnaire from Hammond (2015) also served to examine the ways in which the teachers were reflecting upon their deep cultural values on communication, "doing school," self-motivation, effort, and intelligence. The following excerpt was taken from Clay's questionnaire as he talked about how his cultural values related to effort.

> Hard word was the expectation. My dad worked very long days, and this effort was a model for everyone to follow. If you work hard, you will be successful. By the same token, people who did not have as much [those whom were homeless or with lower paying jobs], were viewed as people who did not work as hard. (Questionnaire)

Although Clay no longer believes that effort is the ticket to the American Dream and he acknowledges social injustices, he knows that his values are so deeply rooted that he has to work extensively to be patient with students who did not exert the amount of effort that he would deem as appropriate on mathematical tasks. While all three teachers spoke of the importance of effort, as discussed in the section on high expectations, Clay's statements stand alone in their deficit point of view. Therefore, it models how pivotal it is for teachers to be overtly aware of their deep cultural values or previously held beliefs and in particular how they might conflict with their students'.

Reflecting upon teaching practices. The journal prompts were instrumental in demonstrating how the teachers were being critical of their practice and working to make revisions. What is also noteworthy is how the teachers gained knowledge through their interactions with students and used this to revise their practice. This domain aligns with Thomas and Berry (2019) on high expectations for teachers and Bonner (2012) with reflections and revisions. In the following reflection, Skylar talks about her CRT practices in her lesson. In particular, we can see that she is pondering what she should have done differently to best reach the needs of her students.

> … I noticed that this was one activity that I didn't put in English and Spanish. I think, I was rushing when making the materials. Because my class is about half Spanish speaking

> children, I try to incorporate their language as much as possible. That is the one CRT thing I wish I had done differently.

Although the previous except illustrates how Skylar was demonstrating awareness surrounding her communication with students, the journal prompts allowed for me to engage awareness on many different CRT practices including that of high expectations which was most discussed in this format when the teachers reflected upon triggers (generally behavioral).

Furthermore, the journals provided insight into effective mathematics teaching practices. For instance, it was a common occurrence for the teachers to talk about how students discussed mathematical representations or strategies that they had not thought of, but how they worked to incorporate the mathematics into the lessons, to examine any misconceptions, and/or to let their voices be heard. In the following excerpt, taken from Elizabeth's journal prompts, further models this finding.

> … I'd thought that my students would only use the strategies I'd taught them for multiplication and division, but one of my students used a strategy that I hadn't considered. A student skip counted backwards by 6's starting with the product of 10 times six to get to the answer of seven times six because he realized that the answer to that was closer than making seven groups of six. It changed my perspective of what application looked like for my students.

What is not documented in this sample evidence is how Elizabeth discussed the boy's strategy with the entire class and later followed-up with the boy who utilized this strategy to learn more about his funds of knowledge and to further understand applications that were relevant to his lived experiences.

Quadrant 2: Learning partnerships. Learning partnerships focuses on how the teachers were forming collaborative relationships with parents and students. When developing learning partnerships with students, the teachers were primarily practicing care and holding students to high expectations both academically and behaviorally. Furthermore, in order to form such partnerships, the teachers were continually gaining knowledge (through various means) from families and students to inform their practice.

Partnerships with families. Prior to the beginning of the school year, all of the teachers discussed how they made attempts to connect with families before their students ever walked through their doors. All three of the teachers worked to set-up home visits with the students' families. During the first interview, Skylar stated that she had two full-days of home visits scheduled, so that she could spend approximately 30 minutes with each family. During this time, she asked the parents about what she should know about their children and whether she was allowed to hug them, she informally gathered information about the students' home life, and she left students with crayons and count-downs until the first day of school. Likewise, Elizabeth and Clay both emphasized the informality of these visits and but how vital they were in building the bridge between home and school.

Although these initial interactions with families were crucial, all of the teachers discussed the variety of ways in which they were constantly attempting to strengthen such partnerships. All three of the teachers mentioned how effective technological resources were throughout this process. For instance, Clay spoke of how he used the ClassDojo application to keep the lines of communication open with his families. Skylar acknowledged how she used the Bloomz application to share pictures, flyers, and updates with her parents and how she appreciated the app because it translated such resources into the parents' native language; and Elizabeth used

Bloomz and sent out weekly emails (in addition to Friday folders) to let parents know of their children's progress in mathematics and to reach out for advice when needed.

Furthermore, the teachers engaged in additional practices to gain knowledge from families, to keep them informed, and to collaborate. Both Skylar and Elizabeth highlighted how they generally sent home surveys to parents to gain knowledge about students and to plan for events. Skylar stated, "I [do] a lot of surveys, because parents they're the number one expert when it comes to their child, and I wanted to make sure I didn't lose anything that they wanted their child to have." Skylar also discussed parent attendance of events and acknowledged how a recent fall festival event was poorly attended; however, rather than focusing on the parents, she claimed that she should have sent surveys out to the parents to determine dates and times that would have best suited their schedules. Similarly, at Willow Elementary, Clay was actively involved in organizing and hosting the parent nights, where one specifically focused on multiplication and division strategies.

Social and educational capital. As Black women, both Skylar and Elizabeth were continually reflecting upon their own experiences and the experiences of historically marginalized youth. This perspective informed the emphasis that they both placed on working with families to gain social and educational capital. Skylar made the following statement:

> We're partners for life and just because your child goes on to kindergarten I will always be here as a support. It's funny because I've had parents who I taught their child in second grade three years ago contact me when they need help or they're trying to navigate the system. And so, I really emphasize that with these preschool parents, because a lot of them this is their first child… As an educator, I am very cognizant about the influence I

> have on the lives of my preschoolers and their families. I want to take on the role of being their support and advocate.

As demonstrated within the previous excerpt, Skylar takes the role of helping her families to develop social capital and navigate such systems quite seriously.

Unlike Skylar, Elizabeth spoke often about being a data driven person. This has caused her to grapple with the role of data and test scores with CRT (and specifically the certification). However, she mentioned how standardized tests, though culturally bias, are the ticket to educational capital in such unjust social structures. She acknowledged on several occasions how being successful on such assessments opened many doors for her in terms of her own educational successes. Therefore, she is an advocate for helping parents and students understand the weight that comes with these tests, particularly as we think about tracking.

The development of critical consciousness (Ladson-Billings, 1994) was not evident with elementary students in the findings, aligning with other literature (Thomas & Berry, 2019). Likely, because the teachers did not feel that such conversations were appropriate or viable with elementary-age students. However, it is noteworthy that two of the teachers were very upfront about developing *consciousness* with parents.

Partnerships with students. Developing partnerships with students was demonstrated consistently in how the teachers modeled care for their students and in how they built upon those rapports to hold their students to high expectations.

Care. Care was witnessed in similar ways as defined by Thomas and Berry (2019) such that teachers were engaged in "a continuous cycle of working to establish a rapport, using knowledge gained from that rapport to inform teaching practices, and then, reflecting upon teaching and learning to understand learners' mathematical knowledge" (p. 26). Furthermore,

having care means that the teachers would go the extra mile to gain knowledge about their students' experiences and honor each student's background and values even if it means that they have to push against their own. For instance, during my first several days in Clay's classroom, I noticed a Latinx boy who was triggering Clay (also noted in his journals); from an outside perspective, I was initially concerned because the boy defiantly refused to join in on group discussions, would sit alone playing with manipulatives, and would at time throw the base-ten rods on the floor. With every outburst, I saw Clay react patiently and positively with care, asking the boy what he could do to meet him half-way as a learning partner. One day after class, Clay shared with me that the boy did not like being part of a Spanish immersion class and he did not like having to speak Spanish. The boy had entered school in non-Spanish speaking classrooms, and by second-grade, he could no longer communicate effectively with his exclusively Spanish speaking parents. Thus, his parents had insisted that he be placed in the Spanish immersion program moving forward. Therefore, Jeff spoke of the importance of honoring the boy's turbulent relationship with school. By the end of my observations, the boy was actively involved in the classroom community and even taking on leadership roles to help Clay.

Another component of care that was highly illustrated with the teachers in this study was how they used proximity to demonstrate to students that they cared for them. For instance, it was particularly noted that when the Latinx boys in Clay's course were grappling with the content and the English instruction, he would walk over to them, and gently place a hand on their shoulder and begin offering clarification in a calm tone, generally in Spanish. Elizabeth practiced proximity by making sure that she was always on the same level (literally) as her students. Thus, when the students were seated on the carpet, she was seated right next to them, both for instruction and to move around and facilitate during independent practice (this also gets into

power dynamics). Likewise, Skylar almost always sat right next to the students, but at the pre-kindergarten level, Skylar did engage in far more instances of having to physically console students in a warm, hugging embrace as a family member would do when the students had emotional reactions. The following vignette models such proximity in Skylar's course.

> Camila is at the back-table group with three other girls for centers. She is being mean to her peers (which is very uncharacteristic), and at one point, she makes Venessa cry. Because Vanessa is so composed, Skylar does not see the interaction taking place. As centers wrap-up, the students check in on the carpet. All of the students sit in their squares except for Camila, who is just standing. Skylar asked her to sit in her square. Camila does not listen to Skylar's instructions. Skylar patiently asked her once again. This time Camila starts crying uncontrollably and she runs toward Skylar to embrace her. Skylar proceeds to finish the lesson which includes carving a pumpkin with Camila holding her tight with her head resting on Skylar's bosoms. As the lesson ends and the other students get ready for lunch, Skylar has a conversation with Camila who is still sobbing. She talks about how she misses her daddy who has been working a lot and who has not been home.

This vignette models not only care through proximity, but it also models how Skylar honored Camila's needs in that moment.

High expectations. High expectations were demonstrated in the ways in which the teachers worked collaboratively with their students to help them set goals and to help them take ownership or establish self-determination of their learning (Ladson-Billing, 1994). This often meant that the teachers had to act as warm-demanders to push the students to establish

independence and to help them to understand the norms that were expected of them within their classrooms.

All three of the teachers in the study had conference times or "check-ins" with their students to not only formatively assess their students but to set plans for moving forward. Although these plans looked differently across the cases, they all embodied similar ideologies. In the following excerpt, we see Elizabeth conferencing with a student during "ketchup and pickle" time; these conferences took place every Friday while the other students worked on assignments from the week (ketchup) that were not yet completed or they had free time to play (pickle) mathematics review games (often with their peers).

> Elizabeth: What were you connecting this [pointing at a past quiz] with? Stop and think about what it means… 4 x 4, not 4 + 4. [Student responds] … You did skip counting. Where do you want to draw your line now [on the worksheet]? [Student points] … It is so beautiful that skip counting is something that you are really good at and I would like to see that on your paper…What about this one [looking at another question on the quiz]? Don't freak out, just stop and think…How did you know to skip count 4 x 4? This one says 1 x 9… You got this skill! Let's keep going. We are going to continue growing. Initially, this was pretty hard, but do you feel like you want to keep practicing or would you want to move on?
>
> Student: Keep practicing
>
> E: I agree but why?
>
> S: [I] want to keep practicing skip counting
>
> E: What did you do this week? … so, the skill practice for this week was skip counting. Let's keep practicing that… [they are now working on identifying rows and columns] … How do you feel about this?
>
> S: Ready to move on
>
> E: I agree because I can see that you are really able to talk about this… The last one that I want you to do is… [pointing at another task; the student does well and Elizabeth is seen celebrating the student's success]. Here you put 9. Using your strategy, you have grown so much. I am so proud of you and I hope that you are proud too. I need feedback. What has been helpful in helping you grow? So, I am going to go down a list and I want you to say "yeah" when you hear something. [they go through a list of instructional strategies

> such as: conference, colored tiles, memorizing, expo, ST Math, Brain pop, and array cards.]

This excerpt models how Elizabeth was checking in with her students and planning for the week ahead. Additionally, it shows how Elizabeth was gaining knowledge from her students surrounding their perspectives of what strategies have been helpful for them in developing understanding of multiplication. The mathematical tasks in this excerpt were not related to students' cultural context.

It should be noted that students often became very upset with themselves if realized that they had not yet earned "pickle" time. I saw numerous emotional outbursts in which the students were frustrated with themselves for not following through and holding themselves accountable. Clay's conferences were modeled similarly as Elizabeth's. However, Skylar's were more subtle in nature given the age of the students. One statement that stands out from Skylar's check-ins with her students was that when the students would say "I can't," Skylar would always correct them by saying, "you can't yet." By emphasizing the "yet," together they focused on how the students could work to accomplish such goals. Also, the teachers had similar impromptu check-ins with students about behavior and/or classroom norms both with independent students and/or the whole-group based upon the circumstances.

Quadrant 3: Community of learners. Establishing a community of learners means that the teachers not only attended to the physical classroom environment, but they also focused on making sure that the environment cultivated within the classroom was one of acceptance, inclusion, and empowerment for the learners.

Classroom environment. Prior to the first day of school, all of the teachers spoke of how they wanted their classrooms to be welcoming for all students. Therefore, the physical space was often a first priority. Skylar made the following statement during her first interview:

> I decided to label everything in the classroom with both English and Spanish labels so that when I talked to my students, if they seemed confused, then I could say it in Spanish too. If parents came into the room, I wanted them to be able to read any message or sign so they could feel connected to our classroom as well.

This practice of displaying vocabulary, instructions, tasks, and activities in both languages around the room was a common occurrence in all of the classrooms. Clay also wrote the mathematical terminology of focus for the day in both English and Spanish on a large poster and placed it on the front board. The rooms were all strikingly multi-cultural including the reading centers which included books representative of many cultures.

During the first couple weeks of school (and throughout the semester), the teachers continued to make efforts to get to know their students and to make them feel at home in the classroom. For instance, Clay had several bulletin boards up with student pictures. One of the boards included pictures of students with their families over the summer. Another included poems that the students had written accompanied by their image (headshot and/or full body). Skylar had similar images and had incorporated graphs on the number of siblings, favorite foods, as well as other information collected from the students. These displays not only helped to create a welcoming environment, but they also helped the teachers to learn about their students, and they helped the students to learn about their peers. In the sections that follow, I examine teaching practices that led to cultivating an accepting and safe classroom environment (rather than just physical space) for learners.

Cultural competency. Cultural competency involved the ways in which the teachers were gaining knowledge of their students' cultural practices and using such knowledge to inform their teaching. This domain aligns with the work of Ladson-Billings (1994) and Thomas and Berry

(2019). For all of these teachers, culturally competency was demonstrated in the ways in which they incorporated movement, music, oral story-telling, and communication patterns (these components are further illustrated in section for relevance). However, drawing upon students' funds of knowledge with language through communication patterns was by far the most emphasized component of cultural competency.

During my initial interview with the teachers, the only one who said that he was fluent in Spanish was Clay; both Skylar and Elizabeth were very modest regarding their ability to speak another language. However, by observing the classrooms, it became apparent that all of the teachers were able to switch back and forth between English and Spanish with ease. When questioned about this, both Skylar and Elizabeth used terminology that indicated that they perceive themselves as being "moderately fluent." Skylar went on to tell me about how she was entirely self-taught and how she practices with her elementary-age daughter. When questioned about her incentive she made the following statement:

> … Some families come to me and they don't speak English, their child doesn't speak English, so that just really set on my heart, like what if this were me in another country where I knew not a word this person was saying, and I am trusting them with my most prized possession, my child, and I don't have another choice. Just my families is the biggest factor.

Furthermore, in the second interview, I asked the teachers about how they make decisions as it pertains to their communication patterns and when they make decisions to switch. Clay specifically spoke of the importance of having his students hear both, both for the Spanish-speaking students to hear English and the English-speaking students to hear Spanish. He felt like this was incredibility important so that students do not fall into habits and so that labels are not

attached to students. On the other hand, Elizabeth and Skylar both grounded their statements in drawing off of the students' energy and actions. The following excerpt illustrates Elizabeth's decision-making process.

> I think the decision is always made when I see... You probably saw it on videos. There are a couple kids that will just disengage, and when they disengage you can see it. You can see the pencil that they're throwing at someone else. You can see that they suddenly are in their notebook, but it's not time to write anything, so what are we doing? And I think with that, it's been more of a constant piece of, "How do I bring you in the conversation?"

The cultural competency that was demonstrated across the classrooms was an intentional move of drawing on the students' funds of knowledge to reorient them with the mathematics that was being discussed and to help them to process the expectations. However, such cultural contexts were rarely demonstrated within the mathematical tasks.

Power. Power encompasses how the teachers were empowering students to take on leadership roles and to develop autonomy, how they were flipping the script when it came to who possessed knowledge in the classroom, and how they were celebrating student successes. This definition of power aligns closely with the work of Bonner (2014). Additionally, there was a strong link between high expectations and power. Skylar made the following statement, "When you give students their independence, you give them power." I thought that this was a profound statement and it models what I was seeing across all of the cases.

Leadership was a significant part of empowering students. It was common to see the students take on leadership roles within the classroom, including during the mathematics instruction. In Skylar's class, there was a little boy named Jacobie who made a habit of having a

certain disregard for the rules. I believe that his behavior was grounded in the fact that he was slightly bored provided that he seemed to be very advanced in mathematics. Skylar would challenge him and empower him by letting him take over the instruction with her guidance. In the following observation excerpt we see this unfold.

> Nine of the students are seated at a table with Skylar. The students each have ten cards. Five of the cards have pictures of objects and the other five have corresponding numerical values (one through five). The students are told to match the cards. Skylar states, "Jacobie, I am going to let Jacobie take over. [repeats in Spanish]. I am letting him be the teacher. Jacobie starts with one. He holds up the one apple and matches it to the numerical value. He moves onto two. Skylar steps in for a moment, "Jacobie, sometimes, I do this [modeling] to check in with students." Jacobie continues to lead, following her example by explicitly counting the objects in the pictures aloud and showing his match to his peers, and then, checking in with each one of them before moving on to the next number.

I witnessed similar incidences play out with many different students across all three classes. Although it looked slightly different in each moment based upon the context and the mathematics being examined, all of the teachers were encouraging students to take the lead in the mathematics instruction at various points throughout the semester. It is important to acknowledge that by allowing for students to take on such roles, the teachers were pushing against the notion that they were the ones with all of the knowledge. Additionally, these small acts were empowering the voices of youth who have historically been silenced in the classroom.

In Clay's classroom, one of the most influential moments was when this transfer of knowledge and power happened with Valentin. Valentin had immigrated to the United States two

years previously and had experienced much adversity. Clay said that in his previous classes he would sit at his desk and cry in silence most of the day, every day. Thus, even when Valentin was disruptive, Clay was just ecstatic that he was present, though he discussed his own triggers in his journal prompts. On the day of discussion, Clay had received high praise from an elective teacher about his class and their dedication to their projects using Minecraft. Although the content was not connected to the current unit, Clay acknowledged that in their projects the students had to build dwellings with entrances, windows, lights, which all accounted to a great deal of mathematical application and reasoning, particularly of spatial awareness and geometry. After an accomplished first part of class, Clay let the students work on their projects in the latter half.

To speak frankly, Clay had no clue how to do much of anything in Minecraft. The students all wanted to help teach him, but it was Valentin who took the lead role in being Clay's partner. He was so proud of himself as he sat patiently beside Clay, going back and forth between his own computer and Clay's and teaching him (literally) how to build the structures. What stood out more than anything else that day was the power of knowledge that Valentin possessed and the huge smile on his face that stretched ear to ear.

All three teachers went to great depth to acknowledge their students' mathematical accomplishments. This praise happened in individual settings (like the conferences previously discussed), during small groups, and whole class discussions. The teachers each expressed wanting to celebrate their students' ideas and accomplishments and to encourage the students to have high expectations for themselves. In the following observation excerpt, Elizabeth is on the carpet working with a large group of students. She split the group in half. She asked the first group to turn and talk with a partner about a strategy for finding the product of three times five

(no cultural context was applied to the task). Meanwhile, she is speaking in Spanish with a group of four students.

> [Re-groups]
> Elizabeth: Alright, talk to me…what is a strategy for multiplication?
> Sarah: Skip counting… 5, 10, 15
> Ray: Or 3, 6, 9, 12, 15
> E: What's a different strategy? Isaac, I saw a really good strategy that you were working on.
> I: Using dots
> E: Of equal rows and columns… That's called an array
>
> Isaac walks up to the board and begins to draw his mathematical representation or strategy. He draws two rows of three dots.
> E: Keep working… how many rows of three do I need?
> [Isaac drew six rows]
> E: Think about what you could do to show 3 x 5 instead of 3 x 6
> [Isaac erases one of the rows and they continue to discuss the strategy].

Although at first, this excerpt may not demonstrate power, this teaching moment carried out throughout the weeks of observation. Every time that the class talked about arrays, Elizabeth referenced to it as Isaac's strategy. Additionally, it is noteworthy that Isaac felt comfortable within their environment to take a risk by walking up to the board to show his strategy. Although Isaac originally drew the incorrect representation for the task that did not discourage Elizabeth from empowering his ideas and his strategy, referring to him as her "brilliant mathematician." She celebrated each one of her students' successes no matter how small using powerful language. There were similar moments like this witnessed across the classrooms with many different students.

Quadrant 4: Information processing in mathematics. Quadrant 4 is the finding that varies the most from Hammond's (2015) *Ready for Rigor Framework* due to the mathematics content. While there are still significant overlaps, the domains discussed in this quadrant build upon teaching practices that are specific to mathematics education research and that attend to

helping students to process information and develop conceptual understanding. These standards-based practices (NCTM, 2000; Walkowiak, Berry, Pinter, & Jacobson, 2018) accompanied with helping students to develop growth mindsets led to students processing the mathematics.

Growth mindset. Hammond (2015) states that a component of information processing includes, "providing appropriate challenge in order to stimulate brain growth to increase intellective capacity" (p. 17). While I witnessed the ways in which the teachers were giving their students tasks that required problem solving, using mathematical representations, and creating communities of discourse, the practice that stood out across all three cases was the attention towards developing growth mindsets (Boaler, 2016) so that students felt more confident in tackling such tasks without experiencing frustration. Thus, developing growth mindsets was a primary priority with all three teachers and acted as an umbrella for the other practices witnessed. The following observation except models what this process looked like in Clay's classroom.

> Clay has given the students a set of problems that each build upon one another and that all address finding the sum of cookies in a bakery on given days. Clay has been very explicit about how they are incorporating Cognitively Guided Instruction (CGI) and how he wants the students to model the problems using different strategies, tools, and mathematical representations. Clay gives the students time to work independently but he begins to notice that when the students cannot find the answers immediately or determine appropriate representations, they begin checking out mentally. Clay looks a little agitated and at one point, I hear him say, "this is driving me bonkers." About 15 minutes in, he calls a whole-group meeting on the carpet. He talked about how the problems made them feel a little uncomfortable because they didn't know what to do right away but that this

> was a feeling that they were going to have to get used to because when you are challenged that's when you are learning. They proceeded by talking about what it means to do math and to be "doers of mathematics."

In the previous vignette, Clay is seen trying to teach his students about what it means to learn mathematics and how grappling stimulates brain growth. In particular, he is emphasizing how they need to confront challenges with a growth mindset. It is also worth noting that these whole-group meetings to discuss the expectations and norms surrounding "doing mathematics" happened quite regularly across all three classes. In the domains that follow, practices, both specific to standards-based mathematics and CRT strategies, are discussed that assisted students in processing information.

Relevance. Relevance is being defined such that the mathematical tasks made connections to daily lived experiences and/or were made relevant by literature and/or media discussed within the class. I want it to be explicitly stated, that the mathematical tasks witnessed were rarely 'culturally relevant," such that the meaningfulness for students was not always clear.

Skylar in particular began nearly every lesson with a children's story or a video. She claimed that these sources ignited learning when following Hammond's (2015) Ignite/Chunk/Chew/Review four macro level instructional strategies. Furthermore, these sources built upon oral storytelling traditions and/or music, provided that many of the video clips incorporated signing, rhythmic movements, and rhyme. These ignite activities often helped students to make connections to themselves and/or their environment. For instance, after watching videos about patterns, the students started to discover patterns on their shirts and on the tile floor. Additionally, Skylar took care to make sure that these ignites translated directly into mathematical lessons.

Elizabeth utilized a great deal of word problems (not culturally specific) within her instruction to unpack multiplication and division and to make it more relevant to the students. These word problems often focused on frogs in lakes, school bake sales, and skyscrapers (windows as arrays). For instance, one of the problems stated: “If there are four frogs in the lake, how many frog legs are there?”. On a few occasions, she incorporated video clips like Brain Pop which disguised a multiplication lesson in a story about bank robbers. The students found the video humorous and entertaining.

Similarly to Elizabeth, Clay also drew upon word problems to make connections. In the context of comparing numbers, he sparked student interest by talking about monetary values and racing competition on the playground. One of the more cultural examples that he incorporated had the students hypothesize over which musical artist, between Taylor Swift, Lil Nas X, and Panic at the Disco, was most popular. He then pulled up data from YouTube to have the students compare the values. When looking at addition and subtraction problems, most of the word problems related to cooking and class recycling competitions. Clay also incorporated numerous mathematical games into his instruction. For example, in one of the partner games, students each rolled dice (three) to create three-digit numbers and to compare their values with those of their partner. The person who created the largest number each round, received a point toward the score. As students advanced, he also let them add more dice. Clay claimed that in these games, the students were learning (comparing numerical values and discussing place values) through play and that they drew upon knowledge from games that many of the students played at home with their siblings and other family members.

Mathematics representations. Hammond’s (2015) discusses the importance of utilizing teaching practices that help students process and make connections to new content. In the

mathematics classrooms observed, the teachers were all using multiple mathematics representations to help students build such connections to new materials. In addition to the presence of representations, the teachers were also modeling and translating from one representation to another (as illustrated in the following excerpt). These acts accompanied with time to "chew" on the information, allowed for students to engage in information processing.

To model this use of representations and the role of representations in information processing, I have drawn upon a teaching vignette in Clay's classroom.

The students have been assigned the following four problems (written format):

1. Kathy had 207 milliliters of water in her cup. She poured out 159 milliliters. How many milliliters of water does she have left? First, estimate. Will it be more or less that 207?

2. Miles had 2,071 milliliters of water in his cup. He poured out 159 milliliters. How many milliliters of water does he have left?

3. Sophia had 23,007 milliliters of water in her cup. She poured out 5,159 milliliters and then drank 150 milliliters. How many milliliters of water does she have left?

4. Create your own problem [English or Spanish]

Prior to letting students work independently, Clay reads the first problem aloud both in English and in Spanish (verbal representation). Additionally, they discuss what the term "millimeter" means in relation to ounces that appear on a student's water bottle. As he walks around the room, he encourages students to use the base-10 rods at their tables to model the first problem and to draw their own pictorial representations on their sheets of paper based upon the concrete representation. After the students have a representation for

number one, he encourages them to connect the representation to the algorithm or the symbolic representation. During this process, Clay notices that Valentin is not actively participating. He walks over to have a conversation with him in Spanish and it becomes apparent that Valentin is not fully understanding the context of the problem. Jeff and Valentine move to the back part of the classroom near a sink. Clay has the water bottle with ounces labeled on the side. He modeled what it means to "pour" water out of the bottle using water from the sink. Valentin watches the ounces on the side of the bottle. Clay and Valentine conclude by talking about how a millimeter is smaller than an ounce (looping back to the initial, whole-group conversation).

This vignette helps to illustrate not only how various mathematics representations were being utilized, but also how they were being connected in ways that helped the students to process the information. Additionally, we see Clay physically representing the situation, as he acknowledges that the language and context of the problem is presenting challenges.

Provided that the teachers were presenting and encouraging the students to use and translate between multiple mathematics representations, it should be stated that they were also encouraging the students to employ multiple strategies. In such ways, the teachers were engaging in equitable mathematics teaching practices, creating multiple access points for students.

Mathematical discourse. Hammond (2015) speaks of the importance of talking to learn or engaging in dialogic talk that is rooted in oral traditions. Hammond (2015) states, "we learn best when we are able to talk through our cognitive routines" (p. 134). Mathematical discourse was present throughout the lessons observed. The three teachers were continually soliciting students' ideas and questions, allowing for peer-to-peer talk, and having students explain and justify their

think, building their intellective capacity. In the following excerpt from Elizabeth's class, the students were thinking about the quotient of eight divided by four (non-contextual).

> Elizabeth: What strategy do you want to use? Start thinking… How am I going to work to solve this? [Students have time to work and talk with neighbors] How did you do it? Okay, so show me… we are going to do a whip around.
>
> Chase: I got eight tiles, and then, I split them into two groups of four.
>
> Elizabeth: Do we agree? Take your time. Think about your answer.
>
> Clarissa: I made four groups.
>
> Elizabeth: So, how many were in each group?
>
> Clarissa: Two.

It is also important to add that every time a student gave an explanation, Elizabeth wrote a representation on the board. In the conversation that followed, Elizabeth and the students talked about fact families and the similarities and differences between the students' methods and representations. The discourse observed in the following vignette also demonstrates how the teachers were asking the students questions to gauge their understanding and simultaneously doing formative assessments.

Limitations

The sampling for participants at the K-2 level was complicated by the fact that the teachers who met these criteria were part of Spanish immersion programs and the mathematics was only delivered in Spanish. Provided that I am not fluent in Spanish, they could not be considered as candidates. During this process, my liaison with the district, Zach, an equity specialist, was most helpful in communicating those teachers across the district who had received certification at the elementary level. Due to challenges that arose while sampling, I do not have a

participant in the K-2 grades. However, the case studies selected each bring insight to this work based upon their unique contexts.

Further, it should be mentioned that the yield of the data collected across the teachers could be considered a limitation. This is because not all of the teachers approached the journal prompts with the same commitment. Elizabeth was by far the most reflective (spending far more than 15 minutes) on the journals while Clay often wrote a brief statement for each question, and on several occasions, failed to complete the prompt.

Discussion & Implications

The findings from this study indicate that teachers who were trained in CRT in the focal district are aligning their teaching practices with the *Ready for Rigor* framework. However, the findings also demonstrate that there are tenets of CRT based upon the works of Gay (2010) and Ladson-Billings (1994) that are more profound in practice in these teachers' classrooms than illustrated in Hammond's (2015) framework. Thus, Hammond's framework was adapted (see Figure 6) to illustrate what was happening in practice. Note that *gaining knowledge* and using knowledge to inform practice is at the core of this model.

Quadrant 1 on awareness aligns closely with Hammond's (2015) first quadrant. Quadrant 2 aligns broadly with Hammond's (2015) perception of partnerships, but in practice, Thomas and Berry's finding of *care* and Ladson-Billing's (1994) framework for *high expectations* are more pronounced. Quadrant 3 also aligns broadly with Hammond's (2015) conceptualization of community of learners but the domains for *cultural competence* and *power* align with the work of Ladson-Billings (1994) and Bonner (2014) respectively. Last, although the ways that the teachers think through providing opportunities for information processing align with Hammond (2015), the practices that they are enacting are evidenced in standards-based teaching (NCTM,

2000). However, it should be explicitly stated that the teachers within this study rarely made the context of the mathematical tasks culturally relevant. The mathematical practices witnessed in this study would be strengthened by making the tasks more culturally relevant to the lived experiences of their students.

The findings expand upon the literature (e.g., Bonner, 2011; Bonner; 2014; Thomas & Berry, 2019) and continue to inform our understanding of how to operationalize CRT in elementary mathematics classrooms in different contexts. However, more work is needed to expand upon this relationship between CRT practices and standards-based mathematics teaching practices. Furthermore, more work is needed to examine how teachers' mathematics knowledge for teaching or mathematics content knowledge impacts CRT practices in elementary mathematics classrooms.

Given that this research focuses on a district that has implemented a CRT professional development certification program and has delineated support structures for CRT enactment, the findings contribute to the literature regarding district level structures that have the potential to influence CRT practices. However, more work needs to be done to examine what specific elements are impacting the teachers' CRT instruction on a daily basis and how they perceive the influence of such elements. Furthermore, the scope of the impact of the CRT certification on the teachers' instruction is not clear without a comparison of the teachers' instruction before certification.

As outlined by Thomas and Berry (2019), although developing critical consciousness with students is a central tenet of CRT, it is often excluded in practice. This study raises questions surrounding the role of culturally responsive teachers of elementary students to develop consciousness with parents. This is an area that has not been fully developed in the

literature. Although, this study contributes to bridging the gap between research and practice with CRT (Cai et al., 2017), it also raises a significant number of questions that call for further dedication to CRT in the field.

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Appendix A

Mapping Cultural Reference Points Questionnaire (Questions from Hammond, 2015, p. 57)

Surface Culture:

- How did your family identify ethnically or racially?
- Where did you live- urban, suburban or rural community?
- What is the story of your family in America? Has your family been here for generations, a few decades, or just a few years?
- How would you describe your family's economic status- middle class, upper class, working class, or low income? What did that mean in terms of quality of life?
- Were you the first in your family to attend college? If not, who did- your parents, grandparents, great-grandparents?
- What family folklore or stories did you regularly hear growing up?
- What are some of your family traditions- holidays, foods, or rituals?
- Who were the heroes celebrated in your family and/or community? Why? Who were the antiheroes? Who were the "bad guys"?

Shallow Cultural Beliefs:

- What metaphors, analogies, parables, or "witty" sayings do you remember hearing from parents, grandparents, aunts, and uncles?
- What family stories are regularly told or referenced? What messages do they communicate about core values?
- Review primary messages from your upbringing: What did your parents, neighbors, and other authority figures tell you that respect looked like? Disrespect?
- How were you trained to respond to different emotional displays- crying, anger, happiness?
- What physical, social, or cultural attributes were praised in your community? Which ones were you taught to avoid?
- How were you expected to interact with authority figures? Was authority of teachers and other elders assumed or did it have to be earned?
- As a child, did you call adults by their first name?
- What got you shunned or shamed in your family?
- What earned you praise as a child?
- Were you allowed to question, or talk back to adults?
- What's your family/community's relationship with time?

Deep Cultural Beliefs (Reflect upon your values related to…)

- Communication (talk and discourse patterns, volume of interactions, etc.)
- Doing-School (Time on tasks, collaboration versus independent work, seat time versus interaction)
- Self-motivation
- Effort
- Intelligence (growth mind-set or fixed mindset)

Appendix B

Journal Prompts Following Observed Lessons

1. Did you have to widen your interpretation aperture? If so, briefly describe how and why.

_____

_____

_____

2. Did you experience any triggers during the lesson? If so, briefly describe when and your reaction(s).

_____

_____

_____

3. Did you experience any emotional reactions? If so, please describe the cause.

_____

_____

_____

4. In what ways did you practice culturally responsive teaching in the mathematics lesson today?

_____

_____

_____

5. Did anything not go as expected? Why?

_____

_____

_____

Appendix C

The First Interview Protocol

1. What were your educational experiences?

2. What is your teaching background?

3. What were your experiences with receiving Culturally Responsive Teaching (CRT) Certification?
    a. When?
    b. Micro-certification or full-day professional development (PD)?
    c. Who led the PD?
    d. Describe portfolio development and presentation.

4. How do you practice CRT with students?
    a. Gain knowledge and use it to inform practice?
    b. Develop relationships? Build bridges between school and home?
    c. Empower students?
    d. Hold students to high expectations?
    e. What is specific to mathematics?

5. What factors influence your CRT practices?
    a. Mathematics content knowledge/Mathematics Knowledge for Teaching/Pedagogical Content Knowledge?
    b. Resources?
    c. Are there structures in place that support your implementation of CRT? In mathematics?
    d. Challenges?

Appendix D

Second Interview Protocol

1. The first interview took place before school started, therefore, please describe the demographic breakdown of the students in your class.

2. Can you describe how your mathematics instruction supports CRT? In particular, is there anything that you feel like you are doing differently this year compared to last year, since you spoke about last year in the first interview.

3. How do you make decisions about communication patterns?

4. Have you attended an PD related to CRT this semester? Please describe.

5. Have you given any PD related to CRT this semester? Please describe.

6. What supports are in place to help you enact CRT?

7. Show them the Equity Model, Figure 5. From your perspective does this accurately illustrate division structures. From your perception, how does this play out? Discuss each tier in the model.

8. Are you continuing to apply the process of CRT certification this year?
    Looking at student achievement data

Appendix E

Observation Protocol

Culturally Responsive Teaching
Awareness (Teacher): -Reflection (personal reflection) -Revisions
Knowledge: -Knowledge of Learners -culture and cultural practices -home/community -funds of knowledge -mathematical identity -Mathematics Knowledge for Teaching -Mathematics Content Knowledge -Pedagogical Content Knowledge
Teaching Practices: -How do teachers learn about their students? -How do they incorporate such knowledge (about learners) into their instruction? -How is the mathematics communicated to students in culturally connected ways? -Does the teacher display cultural competency? -What does the mathematics instruction look like?
Learning Partnerships: -Relationships -Caring -Classroom management/Warm demander
High Expectations for Students: -Self-determination
Power: -Critical consciousness -Agency
Community Partnerships: -Efforts to bridge school and home -Reaching out to parents/families