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Examining Virtual Mathematics Instruction: A Comparative Case Study of In-Service Elementary Teachers with Mathematics Anxiety and Mathematics Teaching Self-Efficacy

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EXAMINING VIRTUAL MATHEMATICS INSTRUCTION: A COMPARATIVE CASE STUDY OF IN-SERVICE ELEMENTARY TEACHERS WITH MATHEMATICS ANXIETY AND MATHEMATICS TEACHING SELF-EFFICACY

by

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ABSTRACT

EXAMINING VIRTUAL MATHEMATICS INSTRUCTION: A CASE STUDY OF IN-SERVICE ELEMENTARY TEACHERS WITH MATHEMATICS ANXIETY AND MATHEMATICS TEACHING SELF-EFFICACY

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Mathematics Anxiety (MA) and Mathematics Teaching Self-Efficacy (MTSE) have been reported as factors related to teachers' mathematics instruction. This study investigated MA and MTSE in in-service elementary teachers' virtual mathematics instruction. A comparative case study design was used to understand the relationship between MA, MTSE, and their virtual mathematics instructional practices. Two in-service elementary teachers from an urban public charter school district in a large metropolitan city in the Midwest participated. I employed qualitative methods to examine the results from the Abbreviated Mathematics Anxiety Rating Scale (AMAS), an adapted version of a researcher-developed instrument called the Mathematics Teaching and Mathematics Self-Efficacy Scale (MTMSE), interviews, teacher classroom observations, post-observation interviews, and a fraction simulation task to learn how teachers approached virtual mathematics instruction. Results indicated the in-service elementary teachers had low to moderate MA and high MTSE when teaching elementary mathematics concepts. However, if they were to have taught higher-level mathematics concepts, then they would have high MA and low MTSE. The in-service elementary teachers who had low to moderate MA and high MTSE heavily relied on direct instructional practices with a focus on procedural strategies.

Also, these teachers experienced many challenges teaching mathematics in a virtual environment. Findings from this comparative case study have implications for teacher preparation programs, mathematics teaching professional development for in-service elementary teachers transitioning virtual mathematics pedagogy, improving mathematics performance for students, and assisting educational stakeholders in improving mathematics instruction.

DEDICATION

To my fathers-Terry Shannon and Rodney Coker; My grandfather, Preston Swope; and my daughter, Assyria Farr

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LIST OF ABBREVIATIONS

MA	Mathematics Anxiety
MTSE	Mathematics Teaching Self-Efficacy
AMAS	Abbreviated Mathematics Anxiety Rating Scale
MTMSE	Mathematics Teaching and Mathematics Self-Efficacy Survey
NCTM	National Council of Teachers of Mathematics
PSSM	Principles of Standards for School Mathematics

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Chapter 1
Introduction

Face-to-face mathematics instruction was interrupted during the 2019-2020 school year by the COVID-19 (coronavirus disease) pandemic. School districts decided to close schools until they could determine how best to educate students during this time. Education was shifted to home environments in March 2020 until the end of the spring 2020 semester (Wise et al., 2020) in hopes that the COVID-19 pandemic would vanish by the 2020-2021 school year. All hope was lost for the 2020-21 school year began with various modes of distance education. Some schools started the school year with 100% virtual instruction, and others implemented a hybrid model that encompassed students learning in-person and virtually. The transition to these instructional modes presented teachers with many challenges as students and teachers had little experience with virtual learning (Kuhfeld et al., 2020). One matter to keep in mind with the transition from traditional learning was students' mathematics performance.

According to the National Assessment of Educational Progress (NAEP, 2019), 41% of fourth-grade students' mathematics performance was at or above NAEP proficient level in 2019, which is not significantly different than mathematics proficiency levels in 2017. What was worse is the mathematics performance for students of color on the NAEP assessment. In fourth grade, 20% of Black students and 28% of Hispanic students scored at or above the proficient level on the NAEP mathematics assessment in 2019 compared to 52% of their White counterparts and 66% of Asian students (NAEP, 2019). The NAEP is an assessment of what students know and can do at grades four and eight in mathematics. Since the NAEP assessment demonstrates students' mathematics performance, it was imperative to investigate teachers' mathematical practices to understand how their instruction impacted students' mathematics performance.

The quality of mathematics instruction impacts mathematics performance for all students (Nelson & 0Sassi, 2007). Teachers should be skilled at teaching mathematics effectively for students' mathematics learning (NCTM's Principles to Actions, 2014). Reform documents established by the National Council of Teachers of Mathematics (NCTM), such as Principles of Standards for School Mathematics (PSSM) and Principles to Actions, emphasized improving mathematics education and mathematics competence for students. However, many urban classrooms fall short of meeting the outlined goals in these documents (McKinney, Chappell, Berry, & Hickman, 2009). High poverty schools are situated in an urban context that service communities that face many challenges. In particular, Black students made up a portion of the population that attended urban schools and were not afforded the mathematics instruction that NCTM and Common Core State Standards for Mathematics supports, improving their mathematics performance (McKinney, Berry & Jackson, 2007). Hispanic students also make up a portion of the population of students served in urban classrooms; hence they are in similar situations as Black students. According to Stutton and Kruger (2002), "the most direct route to improving mathematics [performance] for all students is through better mathematics teaching" (p. 26); therefore, it was imperative to conduct this research study in an urban context.

One definition of quality mathematics instruction consists of making connections among mathematical ideas, maintaining high cognitive demand in mathematics tasks, and promoting mathematical thinking (Liu, 2008). These aspects of quality mathematics instruction are carried out through conceptual and procedural variations that engage students in discussing and solving mathematically challenging problems (Liu, 2008; NCTM, 2014). Factors that impact quality mathematics instruction are teachers' mathematics content knowledge, variations in lesson planning (long- and short-term planning), and making use of curriculum materials (Adeyemi, 2015; Hill, 2008; Liu, 2008). Teachers use of curriculum materials should consider: the timing and pacing of instruction-taking into consideration the number and types of examples to teach mathematical concepts, detailed explanations of those concepts, and making adaptations to materials and the lesson based on students' ability levels (Hogan, Rabinowitz & Craven III, 2003). When examining the quality of teachers' mathematical practices, it is crucial to explore how certain variables may influence teachers' use of curricular materials and the implementation of these materials for instruction. Two variables that should be considered are mathematics anxiety and mathematics teaching self-efficacy.

Mathematics anxiety (MA) is common among many people and is most widespread in college students who major in elementary education (Hadley & Dorward, 2011; Hembree, 1990). Highly math-anxious individuals tend to avoid mathematics either in academic or real-life situations (Ashcraft, 2002; Wood, 1988). Studies have confirmed that students who major in elementary education have one of the highest MA levels among students who major in other fields (Hadley & Dorwad, 2011). Preservice teachers with very high MA levels also struggled to develop lesson plans, teach those lessons, and understand mathematical content (Gresham, 2009). Teachers with high MA levels tend to use more traditional teaching methods such as direct instruction (Gresham, 2018; Hughes, 2016; Iyer & Wang, 2013). Further, high MA teachers are likely to be unsuccessful when teaching mathematics (Unlu, Ertekin, & Dilma, 2017).

Mathematics teaching self-efficacy (MTSE) has been accepted as an individual's belief in their ability to teach mathematics effectively and advance students' mathematics learning (Bates, Kim, & Latham, 2011; Zuya, Kwalat, & Attah, 2016; Lee, Walkowiak, & Nietfeld, 2017; Franks, 2017). MTSE is similar to teacher self-efficacy, although domain-specific and known to be a predictor of mathematics instructional practices (Swars, Daane, & Giesen, 2006). Teachers who have high MTSE are more likely to attempt new and diverse teaching strategies, are innovative, and are comfortable working with students with low abilities learning mathematics (Zuya et al., 2016). Students must learn basic mathematical skills in the early years of elementary school (Maloney & Beilock, 2012). Teachers' pedagogical decisions impact students' mathematics achievement (McKinney, Berry, and Jackson, 2009). Jensen (2018) argued, "with the daily requirements to teach mathematics, [the] constant arousal of anxiety could certainly take its toll on students and elementary school teachers" (p. 6). Research confirmed a link between MA and MTSE (Swars et al., 2006; Gresham, 2009; Franks, 2017; Unlu et al., 2017); therefore, exploring the relationship between these two constructs and their connection with in-service elementary teachers' virtual mathematics instructional practices was the focus of this study.

Research Problem/Context

Mathematics, as an academic subject, is challenging for many individuals. Mathematics is said to be a subject that is not favored by many, provokes negative attitudes, and leads to the experiences of failure (Hembree, 1990). Due to the lack of preparation for rigorous mathematics in higher grades, more attention has been directed toward elementary school students' mathematics education (Berry, Bol, & McKinney, 2009). The short-term impact of this dilemma is the mathematics performance of students at the elementary level. Elementary teachers obtain training in a breadth of subject areas (e.g., mathematics, science, reading, and social studies). Their training may lack the essential depth and understanding in mathematics content and pedagogy to prepare elementary students for rigorous mathematics in higher grades (Berry et al., 2009).

Among students of color nationwide, Black students in grades 4 and 8 performed lower in mathematics than other racial groups at the same respective grade levels (Museus, Palmer, Maramba & Davis, 2011). Similarly, Hispanic students exhibited lower mathematics performance levels in grades 4 and 8, making minor gains than their White and Asian peers. Nonetheless, Hispanics perform at higher levels mathematically than Black students on some mathematics measures (Museus et al., 2011). Most alarming is this trend continues into higher education and STEM-related fields, where Black and Hispanic students make up a small percentage of individuals who complete STEM-related degrees within five to six years (Museus et al., 2011). Overall, Black students fall behind all racial groups from elementary school through the completion of college (Museus et al., 2011). Since students of color make up most of the population of students attending urban schools, they consistently perform at lower levels than other racial groups. Referencing such information showed how important it is for K–12 and post-secondary educators to foster mathematics success within these students' populations seriously. Educators should also consider how the transition from face-to-face mathematics learning to virtual learning impacted students' mathematics performance.

A significant concern with the transition to distance learning was if virtual instruction would be as effective as traditional face-to-face instruction (Kuhfeld et al., 2020). When mathematics was considered, students in K–12 grade could have lost between a few months and a year's worth of mathematics learning and made less progress in mathematics due to the COVID-19 pandemic (Loewus, 2020). An additional challenge was teaching mathematics virtually, which was hard for teachers (Loewus, 2020). Teachers had to make many adjustments to teach mathematics virtually. Teachers reduced the amount of instruction, mathematics content, and assessments given to their students and the amount of time students spent learning mathematics (Wyse et al., 2020; Loewus, 2020). These concerns were significant when considering students' mathematics learning and students' overall mathematics performance.

Research Significance and Aim

Elementary school is traditionally comprised of grades 4K—5. Students explore advanced topics including geometry, algebraic thinking, number and operations in base ten, measurement and data, and fractions in these grades. Students also begin to form attitudes and beliefs about mathematics and what it means to know and do mathematics at this level (Reys & Fennell, 2003). Elementary mathematical concepts, applications, and skills are foundational for preparing middle and high school mathematics students. Without this solid foundation, it might be difficult for students to make the necessary connections to future mathematical topics (Wriston, 2015). Students in grades K-5 who learn by memorizing and imitating are unlikely to develop a conceptual understanding of mathematical topics or be interested in them in later grades (Reys & Fennell, 2003). NAEP data showed that over 50% of students in the United States were performing at the basic level in mathematics in fourth grade, which means students partially mastered prerequisite knowledge and skills necessary for proficient work (NAEP, 2019). Students of color represented many of these students (NAEP, 2019). Students of color were exposed to limited factual knowledge and computational skills (McKinney, Chappell, Berry, & Hickman, 2007; NCTM, 2000); therefore, it was essential to situate this study in an urban context. Further, it was necessary to explore how MA and MTSE might influence in-service elementary teachers' virtual math instructional practices because many of the concepts students struggle with are basic arithmetic. They learn this in the elementary grades.

A great deal of literature has documented preservice teachers' MA (Ashcraft, 2002; Bates, Latham & Kim, 2013; Bekdemir, 2010; Gresham, 2009; 2018; Hadley & Dorward, 2011; Ma, 1999; Morton, 2018; Peker & Ertekin, 2011; Wood, 1988). Preservice teachers with higher MA levels teach differently from preservice teachers with lower MA levels (Haciomeroglu, 2013).

Those with high MA tend to adhere to textbook-driven information and use lecture-based instruction, while those with low MA use student-centered strategies. MA can result from various factors and often lead to an avoidance of mathematics-related courses and careers and creates negative attitudes toward the subject in general (Ashcraft, 2002; Gresham, 2018). Some teachers experience MA and believe their instructional practices are ineffective when teaching higher elementary grades and decide to teach first or second grade or leave the teaching profession (Gresham, 2018). Also, teachers with MA rely on teaching practices such as administering workbook pages and independent exercises without modeling or engaging students to understand the meaning of mathematics (Gresham, 2018).

MTSE has been studied with preservice teachers. MTSE was often used interchangeably with constructs as teacher self-efficacy, mathematics self-efficacy, and mathematics teacher efficacy. Research revealed that preservice teacher's teaching self-efficacy impacts their choice of instructional methods and classroom environment, ultimately affecting both students learning and self-efficacy. According to Zuya et al. (2016), "students learning of mathematics can be affected either positively or negatively depending on whether the teacher has high or low sense of MTSE" (p. 94).

When investigating teachers MA and MTSE, it is also vital to examine their mathematics instructional practices to understand how these constructs might influence mathematics instruction and students mathematics learning. In doing so, a comparative case study was used to investigate teachers' virtual mathematics instructional practices since some teachers transitioned their instruction to a virtual setting for the 2020-2021 school year. Virtual mathematics instruction was new for many teachers. A lot of thought and consideration took place to transition their traditional teaching practices and materials for the virtual setting. A comparative case study helped the researcher dig deep into the attitudes, perceptions, backgrounds, learning experiences, and mathematics teaching practices of urban in-service elementary teachers. It also allowed teachers' voices to be heard to understand better how their MA and MTSE manifested in their virtual mathematics instructional practices.

Exploring how urban in-service elementary teachers' mathematics experiences influenced their instructional practices could shed light on new strategies to improve mathematics teaching and learning for individuals with MA and low MTSE. Also, investigating in-service teachers' virtual mathematics instructional practices could transform traditional mathematics instructional practices. Results from this study can expand upon the current MA and MTSE research to enlighten connections about teachers' mathematics instructional practices in the elementary classroom. Recent research shows a gap in the relationship between MA and MTSE with urban in-service teachers' virtual mathematics instructional practices in the United States at the elementary level.

Purpose Statement

The purpose of this comparative case study was to explore the relationship between MA and MTSE and explain how in-service elementary teachers approached virtual mathematics instruction, particularly in the area of lesson planning and implementation. Further, this study sought to explain what in-service elementary teachers perceived about their MA and MTSE and how those perceptions formed their ideas, preparation, and execution of their virtual mathematics instruction. This comparative case study was conducted to represent a common case in that it is normal for teachers to have some anxiety and various levels of confidence when teaching mathematics. This case study also described an unusual situation in that teachers had to teach mathematics in a virtual setting which was different from their usual teaching environment. Yin

(2014) explained that an unusual case deviates from everyday incidents, and a common case captures the conditions of an everyday situation.

The study was designed to provide insight into the relationship among MA, MTSE, and in-service elementary teachers' virtual mathematics instructional practices. The goal was to explain how MA and MTSE influenced teachers' virtual mathematics instruction and how they approached teaching mathematics virtually. Therefore, this study's results illuminate the relationship between these constructs, thus informing teacher preparation at all education levels and enhancing the mathematics instruction of elementary teachers. Further, this case study's results can provide awareness of necessary professional development related to MA and MTSE, virtual mathematics instruction, enhancing mathematics lesson planning, and engaging students in conceptual problem-based mathematics tasks.

Research Questions

To understand the relationship between MA and MTSE and urban in-service elementary teachers' mathematics instructional practices, the driving questions for this study were:

1. How are MA and MTSE characterized in in-service elementary teachers?
2. How do virtual mathematics instructional practices vary among in-service elementary teachers with different profiles of MA and MTSE?

Research Design

A comparative case study design was chosen to analyze the similarities, differences, and patterns across two cases (Goodrick, 2014). This study used an explanatory approach consisting of two cases to explain how MA and MTSE interacted and influenced in-service elementary teachers' mathematics lesson planning and implementation. Exploring answers to the research questions were approached qualitatively using surveys followed by mathematics lesson plans, interviews, teacher class observations, post-observation interviews, and a fraction simulation task. Qualitative methods explained how each teacher described their MA and MTSE and how these constructs influenced their mathematics lesson planning and virtual mathematics instructional practices. Speaking directly with in-service elementary teachers about their experiences learning and teaching mathematics through interviews gave a deeper insight into their thoughts and feelings toward mathematics and teaching mathematics virtually.

Bandura's (1977) self-efficacy theory was used as a lens to focus on in-service elementary teachers' past experiences learning mathematics and how those experiences shaped their MA and MTSE. According to Bandura (1995), perceived self-efficacy refers to an individual's belief in their capability to create and perform actions needed to manage potential situations. Further, self-efficacy beliefs determine how individuals feel and motivate themselves (Bandura, 1995). An individual's *self-efficacy* can be understood through four sources of efficacy expectations: mastery experiences, vicarious experiences, social persuasion, and physiological and emotional arousal. The possible outcomes of these four sources are displayed in Figure 1.

1. Mastery experiences: an individual achieves success, which boosts their confidence in their abilities and future performances. Repeated failure lowers one's belief.

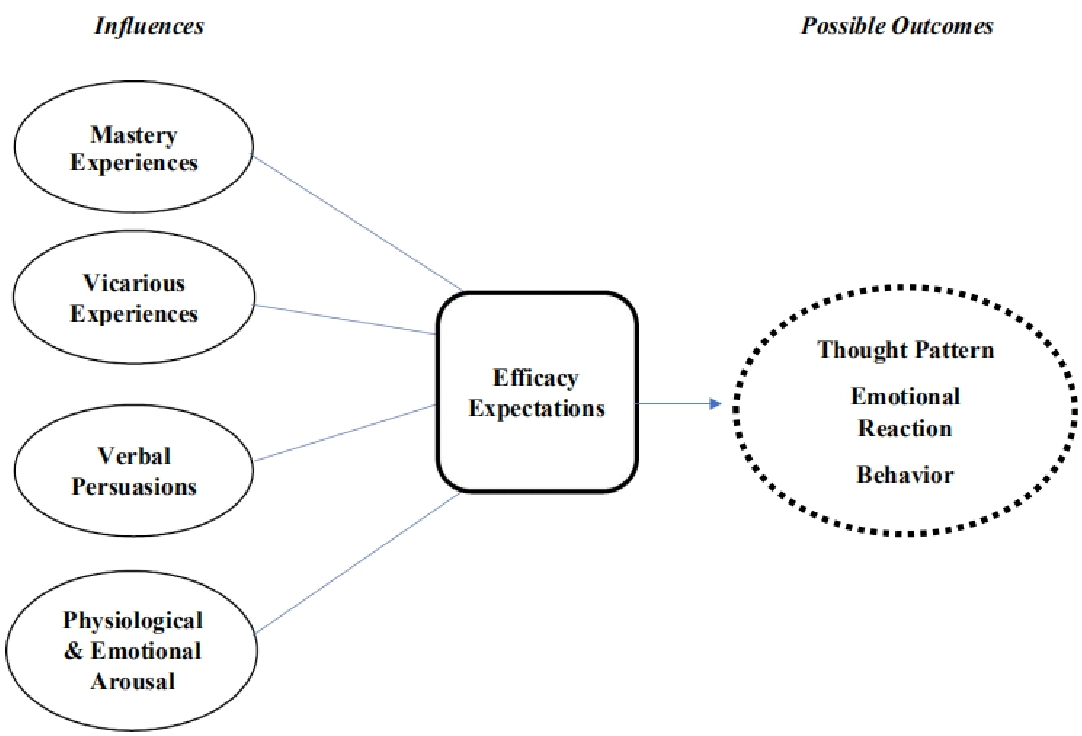
2. Vicarious experiences: an individual observes a similar person who has success with a task, which increases the individual's belief in themselves. Poor performance decreases efficacy expectations.

3. Social persuasion: an individual receives encouragement or is verbally persuaded that he or she is capable of mastering a given activity.

4. Physiological and Emotional Arousal: an individual's emotional state determines their capability to perform a given activity. (Bandura, 1977)

Figure 1

Self-Efficacy Theory Outcomes



These four sources of self-efficacy contribute to examining teaching tasks and self-perceptions of teaching competence in different ways (Tshannen-Moy, Hoy & Hoy, 1998), which affects the dynamics of the classroom structure, the teacher, and students. Furthermore, these sources were examined to understand how an individual's self-efficacy toward mathematics was developed.

Ten in-service elementary teachers that taught 4th and 5th-grade in an urban metropolitan charter school district were the targeted population. All teachers who identified as teaching mathematics as part of their teaching assignment were participants of this study. Teachers were informed their participation in this study was voluntary. Teachers who were interested completed a letter of consent and submitted it via email and through Qualtrics. Interviews were conducted with in-service elementary teachers that completed both surveys.

Next, lesson plans from teachers were solicited to examine how teachers planned virtual mathematics instruction. More specifically, how teachers designed engaging lessons, the mathematical tasks designed: procedural or conceptual, and the type of curriculum used. Teacher classroom observations were conducted to assess in-service elementary teachers' virtual mathematics instruction to cross-reference information obtained from the surveys and interviews. During classroom observations, the researcher observed time spent on mathematics-related instruction and activities. Additionally, the researcher observed types of mathematical tasks that promoted procedural or conceptual understanding, mathematical questioning to promote conceptual mathematics understanding, and if teachers used diverse instruction methods (i.e., group work, manipulatives, student-led problem solving, and direct instruction). Post-observation interviews were conducted to clarify actions observed during classroom observations and reflect on interesting instructional aspects. Lastly, a fraction simulation task was used to assess teachers' instructional approach and confidence in teaching a mathematics concept deemed challenging to teach and learn.

A qualitative approach (Creswell & Creswell, 2018) was the best way to draw on elementary teachers' thoughts and perceptions about mathematics. Further, how these thoughts and perceptions related to their virtual teaching practices combined with the mathematics anxiety rating scale and the mathematics teaching and self-efficacy survey. Using a quantitative approach would not allow the researcher to capture the stories elementary teachers had about their experiences learning and teaching mathematics. In-service elementary teachers' voices can bring more awareness to their experiences and spark the attention of stakeholders who can assist in improving mathematics teaching and learning.

Definitions

In-service elementary teacher- A practicing teacher who teaches any grade ranging from first through fifth.

Elementary Grades- Grade levels comprising kindergarten through fifth grade.

Self-Efficacy- A cognitive process by which individuals construct beliefs about their capability to perform at a certain level of attainment (Tshannen-Moran et al., 1998).

Virtual Learning- Instruction occurring in one of the following formats: synchronous, asynchronous, and distance learning.

Urban Setting-An area or school typically located in a large city of fewer than one million people that face the following challenges: a lack of resources, qualification of teachers, and academic development of students (Milner, 2012). This population is made of people of color.

Chapter 2
Literature Review

This chapter presented a review of existing research literature on MA, MTSE, and these constructs' relationship with in-service elementary teachers' mathematics instructional practices to include virtual instruction. The research was synthesized to focus on self-efficacy theory as a lens for understanding MA and MTSE. Second, a literature review on MA: its onset, impact on teachers, their students, and females. Third, a review of literature on MTSE: its onset and impact on mathematics instruction. Fourth, an overview of examined literature on MA and MTSE. Fifth, literature regarding virtual mathematics instruction followed by mathematics instruction in urban settings. Another section of literature on mathematics education and two popular mathematics instructional methods. The final section summarized the existing literature and highlights the significance of the current study in mathematics education.

I used several search strategies and databases to identify relevant literature. I used the Education Resources Information Center (ERIC) EBSCO and Education Research Complete databases along with Search @ UW, an interdisciplinary tool, and Google Scholar for any search of the following keywords: urban schools, mathematics instruction, MA, MTSE, in-service elementary teacher, practicing teacher, mathematics, and online mathematics instruction. I limited the resources to peer-reviewed journal articles, dissertations, and books published between 2000--present. I also referred to the references of primary sources that resulted from this search.

Theoretical Framework

I adopted the theoretical framework of self-efficacy conceptualized by Albert Bandura (1977) as a lens to understand MA, MTSE, and teachers' mathematics instructional practices.

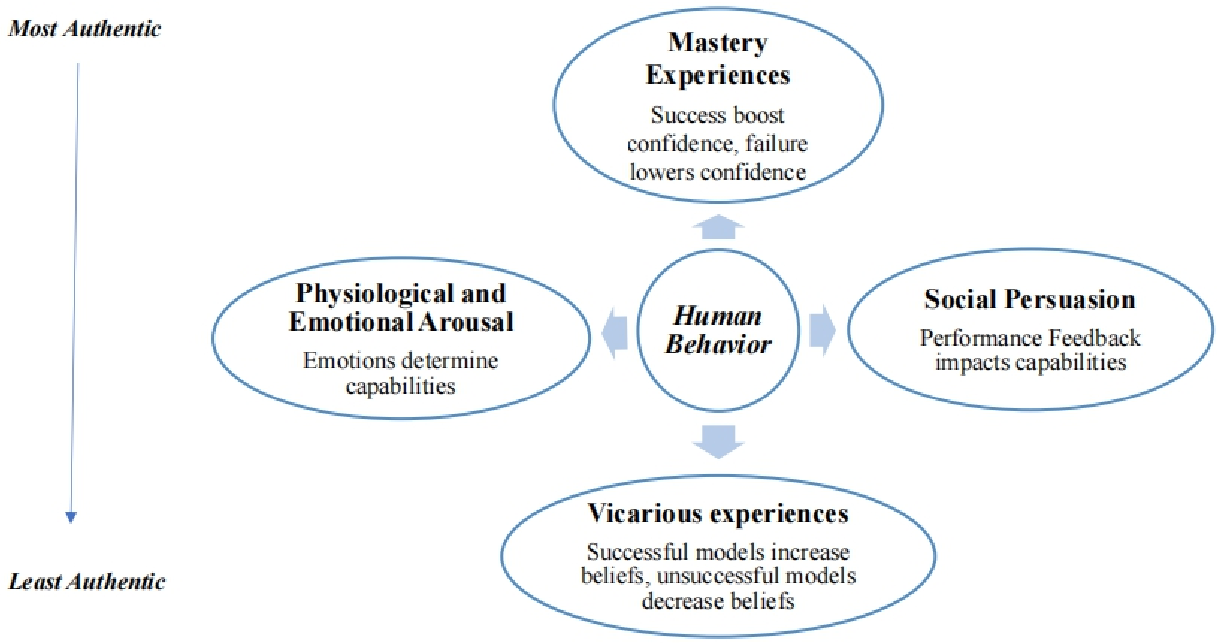
Self-efficacy is a cognitive process in which individuals formulate beliefs about their ability to perform at a given level of achievement (Tschannen-Moran et al., 1998). Efficacy beliefs influence how people think, feel, motivate themselves, and act. What motivates a person and their actions is based more on what they believe about their competence than their actual competence to accomplish a task (Bandura, 1977). Bandura studied efficacy beliefs in two forms-*personal self-efficacy* and *outcome expectancy* and applied these constructs to teaching. *Personal self-efficacy* is the belief that one can accomplish the behavior necessary to produce outcomes.

In contrast, *outcome expectancy* reveals the teacher's perception of students' ability to learn from their teaching (Newton, Leonard, Evans, and Eastburn, 2012). *Outcome expectancy* will not be used as a lens because the purpose of this research was to focus solely on teachers' perceptions of their ability to teach, not their perceptions of student learning based on their ability to teach. The psychological aspects of personal self-efficacy were a lens through which this study was designed since it concentrates on an individual's judgment about their teaching ability. Understanding how strong a person's beliefs are in their efficacy can affect how they approach various situations that may be anxiety-producing.

According to Bandura (1997), individuals are inclined to avoid threatening situations they believe surpass their coping skills. In contrast, individuals take part in activities and behave with confidence when they feel capable of handling situations that would otherwise be intimidating. The bottom line is efficacy expectations regulate the amount of effort individuals will distribute and how long they persist when faced with obstacles and unpleasant experiences (Bandura, 1997). An individual's belief about their efficacy can be understood through four primary influences: mastery experiences, vicarious experience, social persuasion, and physiological and emotional arousal. Figure 2 summarized these four self-efficacy expectations indicating the direction of impact.

Figure 2

Self-Efficacy Expectations Summarized



Mastery Experiences

Mastery experiences "provide the most authentic evidence of whether one can muster whatever it takes to succeed. Successes build a robust belief in one's self-efficacy. Failures undermine it, especially if failures occur before a sense of efficacy is firmly established" (Bandura, 1995, p. 3). Further, successes increase mastery expectations while repeated failures decrease them, mainly if these failures occur early in events. After strong efficacy expectations are developed through repeated success, the negative impact of occasional shortcomings is likely to be reduced (Bandura, 1977). This assumption will be a perfect lens to utilize when researching elementary teachers' self-efficacy about teaching mathematics. Many of their views about mathematics come from past experiences learning mathematics and their mathematics teaching experiences. A teacher's perception of his/her teaching performance during a lesson can either increase or decrease efficacy beliefs. If the account was successful, self-efficacy beliefs increase, then the expectation is that future performances will also be successful. If the performance was unsuccessful, self-efficacy beliefs decrease, then one's expectancy is that future performances will also be ineffective. The attribute that influences mastery or incompetence is the level of arousal, either anxiety or enthusiasm (Tschannen-Moran et al., 1998). Mastery experiences are not the sole source of evidence regarding individuals' self-efficacy levels. Several expectations result from vicarious experiences.

Vicarious Experiences

The second source of self-efficacy, *vicarious experiences*, is observing someone similar to oneself succeed at a task, which increases that individual's belief that they are also capable of completing similar activities (Bandura, 1995). However, the reverse effect results when seeing someone fail, despite their efforts, lowers the observer's judgment about their abilities. This efficacy source helps examine preservice teachers' self-efficacy beliefs about teaching mathematics since they are required to participate in student teaching. As it relates to in-service teachers, to gain a sense of this efficacy source, one would have to interview teachers about possible experiences observing others teach.

Social Persuasion

Social persuasion is strengthening one's belief that one has what it takes to be successful. This efficacy expectation source may entail a pep talk or detailed performance feedback from a supervisor, colleague, or student. Bandura (1995) explained, "people who are persuaded verbally that they possess the capabilities to master given activities are likely to mobilize greater effort and sustain it than if they harbor self-doubts and dwell on personal deficiencies when problems arise" (p. 4). Efficacy expectations from this source tend to be weaker than those that result from an individuals' accomplishments, for they do not offer genuine experiences for them. However, it could contribute to successful performances to the extent that a persuasive boost in self-efficacy guides one to initiate or attempt new strategies or tasks and put forth an effort to succeed (Tchannen-Moran et al., 1998).

Physiological and Emotional Arousal

Lastly, individuals depend on their *physiological and emotional arousal* to judge their capabilities. When they encounter stressful and difficult situations, they relate these experiences to poor performances. Individuals can interpret their stress reactions and tensions as signs of low-performance vulnerability (Bandura, 1995). Further, high arousal such as increased heart and respiratory rate, trembling hands, or butterflies can be signs of stress and anxiety or excitement depending on an individuals' history (Tchannen-Moran et al., 1998). In the perspective of MA and MTSE, an individual can conjure up fear-provoking thoughts about their ineffectiveness and arouse themselves to elevated levels of anxiety that exceed the fear experienced during the actual intimidating situation (Bandura, 1977). More importantly, higher levels of arousal can weaken functioning and interfere with an individual making the best use of their skills and capabilities (Tchannen-Moran et al., 1998). If a teacher feels positive about teaching, their emotions signal confidence, and they anticipate success. On the other hand, if they feel anxious about teaching, they expect failure. This efficacy expectation source is vital to consider, as it is informative for determining the level and direction of motivational incentives to action (Bandura, 1977).

These efficacy expectation sources of *personal self-efficacy* can help individuals determine their capabilities in performing a specific task. According to Tchannen-Moran et al.

(1998), individuals develop predispositions based on prior beliefs, the sorts of acknowledgments they make, and the sources of information they attend to or consider important. In other words, individuals could have many reasons or justifications for their actions and see themselves or others as agents employing control, blaming others, or assuming personal responsibility for failure. Each of these efficacy expectation sources can be applied to understand different aspects of an individual's feelings about and their ability to teach mathematics. It appears that mastery experiences and physiological and emotional arousal can reveal more information into a teacher's self-efficacy beliefs about mathematics and teaching mathematics to students. Social persuasion and vicarious experiences may disclose underlying information that may not be as obvious as the former two efficacy expectations.

Mastery experiences, verbal persuasion, and physiological and emotional arousal may give insight into individuals' MA. All of the efficacy expectations could bring awareness about an individual's MTSE and their virtual mathematics instructional practices. Since Bandura presents self-efficacy through cognitive processes, this determines how the information will be used, how it influences the analysis of an individual's MA and MTSE, and the assessment of teachers' virtual mathematics instructional practices.

Bandura's self-efficacy theory helped to understand the interaction of the environment, intellectual and personal factors that relate to the development of MA and MTSE in in-service elementary teachers' virtual mathematics instructional practices. These three factors interact with one another to influence individuals' beliefs and actions. They are not inactive or independent; instead, they function as interrelating factors of each other (Adeyemi, 2015). Bandura (1989) explained that human agency- humans' ability to make decisions and impose those decisions on the world affects environmental, intellectual, and personal factors. When individuals make decisions, these decisions influence the environment they are in and the people they interact with, and their behaviors (Adeyemi, 2015). When using Bandura's theory to understand MA and MTSE, environmental factors are considered. These factors include negative academic experiences in the classroom and mathematics experiences in home and community settings. Intellectual factors consist of an individual's negative attitude related to mathematics, insecurities, and lack of confidence in mathematics abilities. Personal factors include an unwillingness to ask questions due to shyness, low-self esteem, and mathematics as a male-dominated field. Now, I review literature related explicitly to MA, MTSE, and effective mathematics instruction.

Mathematics Anxiety

The literature suggests that math anxious individuals avoid college and career paths that rely on mathematics skills (Ashcraft, 2002). The literature also supports the idea that MA was prevalent among college students who major in elementary education. According to Hadley and Dorward (2011), "studies have consistently shown that elementary education majors have one of the highest levels of mathematics anxiety on college campuses" (p. 28). The concern is that elementary teachers have an essential duty to stimulate excitement for learning all academic subjects to include mathematics; however, it might be difficult to expect them to generate enthusiasm and excitement for mathematics if they have anxiety toward it (Wood, 1988). In addition to this concern, Boyd, Foster, Smith, and Boyd (2014) argued, "preservice teachers in the USA and Australia experience higher levels of mathematics anxiety than other university undergraduate students, with the incidence of mathematics anxiety significantly higher among elementary (early years) education students" (p. 208). While most of the research around MA focuses on elementary age through college-age students (Smith, 2010) and preservice elementary teachers, there have been significantly fewer studies on MA of in-service teachers.

The few studies that have shed light on the experiences of in-service elementary teachers' MA report that many experience high levels of MA and hold traditional beliefs about mathematics instruction (Bates, Latham & Kim, 2013; Hadley & Dorward, 2011; Hembree, 1990; Hughes, 2016; Wood, 1988). The MA research is extensive, stimulated by an increased awareness that this construct threatens student performance and participation in mathematics. Gersham (2018) stated, "once in the workforce, teachers might find it particularly challenging to shake any affective discomforts. Particularly as it pertains to mathematical confidence or beliefs, mathematical thinking, and any negative feelings/emotions they may experience toward mathematics and teaching the subject" (p. 90). Students are aware of their surroundings and can pick up their teachers' discomforts (Hadley & Dorward, 2011).

MA has been studied for many years. According to Unlu et al. (2017), "the sense of anxiety results from the withdrawal of support, expecting negative consequences, internal conflicts and uncertainty [and] mathematics is a domain that can raise anxiety among individuals" (p. 637). The first researchers to study MA were Richarsdson and Suinn (1972) when introducing the Mathematics Anxiety Rating Scale (MARS). A few years later, the construct of MA became increasingly popular when Tobias (1978) published her book, *Overcoming Math Anxiety*. Feelings of MA are common in the United States. Nearly 25% of 4-year college students and 80% of community-college students suffer from a moderate to a high MA level (Beilock & Maloney, 2015). More alarming is that nationally, MA is linked to decreased mathematics performance and can persist 20 years or more influencing major life decisions related to additional education, career choice, and everyday life (Beilock & Maloney, 2015; Morton, 2018). Elementary teachers have the highest levels of MA rates compared to teachers at other grade levels. Hadley and Dorward (2011) found that between 17 and 40% of in-service elementary teachers had MA. Hence, MA is a critical factor for student learning as well as teaching effectiveness. Research is needed to determine how MA and MTSE relate to in-service elementary teachers' virtual mathematics instructional practices related to their mathematics lesson planning and implementation. Before delving further into MA in elementary teachers, I explain the construct of MA in the next section.

Mathematics Anxiety Defined

MA has been defined in many ways. Some scholars describe it as an emotional construct, while others use a more practical explanation. Hunt (1985, as cited in Wood, 1988) stated,

> some scholars do not in any way link their definition to school mathematics but rather use the term math anxiety to describe the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem (p. 8)

This definition reflects the power of MA. A glimpse into this situation was given by a teacher who said, "calculating the tip in a taxi was often so distressing that [I] preferred to walk, carrying heavy suitcases rather than experience such discomfort" (Donady & Tobias, 1977, as cited in Wood, 1988, p. 8). Richardson and Suinn (1972, as cited in Wood, 1988) said MA "involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 8). This definition emphasized the actual effect of MA in mathematics performance rather than the emotional impact. Another definition sought to convey MA as "a general fear of contact with mathematics, including classes, homework, and tests" (Hembree, 1990 as cited in Hadley and Dorward, 2011, p. 28). This definition spoke to a possible avoidance of mathematics-related tasks. The issue arises when finding the most applicable MA definition because many scholars do not exactly use the term MA but speak about the anxiety individuals experience while they do mathematics (Wood, 1988).

For the current research, I defined MA as expressing the general lack of comfort an individual might feel when thinking about, performing, and teaching mathematics. Moving forward with this definition, I expand the discussion of MA by considering factors leading to the possible onset of MA.

The Onset of Mathematics Anxiety

When MA was discussed, it usually concerned the consequences and rarely the antecedents. The causal factors of MA can be understood by classifying variables that systematically relate to MA development. Suggested origins of MA included environmental factors, intellectual factors, and personal factors (Bekdemir, 2011; Hadfield & McNeil, 1994; Peker, 2009; Peker & Ertekin, 2011). These components are defined as follows:

- Environmental factors include negative experiences in the classroom, family context, teachers' characteristics and instructional practices, and mathematics as a male-dominated subject.
- Intellectual factors include low persistence and lack of confidence in mathematical ability.
- Personality factors include negative attitudes, reluctance to ask questions due to shyness, low self-esteem, self-doubt (Bekdemir, 2011; Eden, Heine, and Jacobs, 2013; Hadfield & McNeil, 1994)

These aspects summarize various experiences that individuals with MA have encountered. According to Brown et al. (2011), individuals have negative experiences that include "memories of struggling with particular concepts such as fractions or long division; embarrassing moments of making mathematics errors in front of peers; past teachers that were viewed as hostile or uncaring; and gender-biased issues of mathematics schooling" (p. 2). Looking more closely at these factors can help one understand how an individual may have begun to experience MA.

Environmental Factors of Mathematics Anxiety

Many researchers have agreed that MA initially develops during elementary school (Isiksal, Curran, Koc & Askun, 2009; Maloney & Beilock, 2012; Morton, 2018; Smith, 2010; Unlu et al., 2017; Van der Sandt & O'Brien, 2017) while others documented secondary school (Bekedemir, 2010; Brown et al., 2011). Sixteen percent of students reported that their first negative experience with mathematics took place by either third or fourth grade (Brown et al., 2011; Van der Sandt & O'Brien, 2017); 26% recalled their first negative experience in secondary school (Brown et al., 2011).

Bekdemir (2010) performed a study in Turkey that focused on preservice teachers' worst experience and most troublesome mathematics classroom experience and found that the grades in which MA first developed was 9th through 11th grade. Bekdemir (2010) explained, "the percentage of students who had negative experiences went up with the transition from the elementary and [middle] school to high school level" (p. 324). This circumstance can be explained in two ways: classroom environmental issues experienced by preservice teachers and the complexity of learning mathematical content students in general experience.

Firstly, preservice teachers, when students did not receive the help and support needed when struggling to learn mathematics. These teachers reported that they were exposed to adverse behaviors of their teachers. The preservice teachers believed that their teachers would compare students' mathematics improvement, scold and annoy them, and laugh at them (Bekdemir, 2010). In the study conducted by Brown et al. (2011), participants reported that their MA resulted from insensitive teachers from their past who supposed mathematical concepts were straightforward although students did not comprehend them. Additionally, Peker (2009) also explained that preservice primary school teachers' negative experience and mathematics anxiety were attributed to their teachers instead of other factors as mathematical concepts, parents, or peers. Overall, teachers who identified elementary or secondary grades as starting points for their MA believed that it resulted from negative experiences learning mathematics in academic environments with teachers that did not show care and concern for students' mathematical understanding and learning. Not only did individuals speak to their teachers' dispositions, but also the instructional methods that initiated their MA. According to Boyd, Foster, Smith, and Boyd's (2014) study, preservice teachers discovered that their teachers' pedagogical approach to teaching mathematics was associated with negative attitudes toward mathematics. These factors contributed to their MA. Regarding attitudes, one could consider that an individual's opinions or thoughts about something indicate their attitude toward that case. Having a negative attitude toward mathematics refers to the level of like or dislike an individual feels toward mathematics (Quinn,1997).

Secondly, as students move to higher grades, mathematical topics became more complex and abstract. If students did not understand mathematics in lower grades, it would be challenging for them to comprehend and expand upon new information. Further, negative experiences in lower grades may reduce motivation and unpleasant attitudes toward mathematics during a person's life (Bekdemir, 2010).

Contrary to the idea that MA results from individuals' experiences with teachers and their instruction, some researchers attribute teachers' MA to their parents (Gresham, 2018). Parental attitudes can also influence individuals' mindsets toward mathematics (Eden, Heine, and Jacobs, 2013). A parent's belief about their child's mathematical capabilities is systematically connected to a student's mathematical self-efficacy beliefs and performance scores (Eden et al., 2013). Suppose parents have beliefs that differ based on gender and expectations for their child's academic subjects' competencies. In that case, this could play a critical role in affecting their child's self-perception and skill achievement in mathematics (Eden et al., 2013).

Intellectual and Personal Factors of Mathematics Anxiety

Teachers' behavior in the classroom has also been identified as a factor contributing to MA (Bekdemir, 2010; Unlu et al., 2017). Their attitudes about mathematics and lack of support for understanding can produce mathematics avoidance and anxiety in students. Attitudes toward mathematics are important to consider due to the reciprocal relationship between mathematics achievement and an individual's attitude toward mathematics (Evans, 2011). Negative attitudes on the part of teachers impact students' values and attitudes about mathematics and teachers' effectiveness in teaching mathematics and their mathematical abilities (Ashcraft, 2002; Van der Sandt and O'Brien, 2017). Gresham (2009) explained, "teachers had concerns with their abilities to teach students due to their own [MA] levels, which ultimately resulted in their negative attitudes towards mathematics" (p. 26). Teachers' attitudes can be determining factors in how they approach teaching mathematics. These attitudes are important to consider, especially if negative attitudes are exhibited. MA threatens both achievement and individuals' participation in mathematics (Hembree, 1990). Generally, this is not the case for every individual, but the principle might inform why MA and negative attitudes toward mathematics exist.

Teachers are responsible for promoting positive attitudes about mathematics instead of negative ones, ultimately impacting their instructional practices. Teachers' negative attitudes about mathematics have been linked to MA (Gresham, 2018). According to Lake and Kelly (2014, as cited in Gresham, 2018),

> negative attitudes toward mathematics can produce negative achievement in mathematics due to the reduction of effort expended toward the activity, the limited persistence one exerts when presented with an unsolved problem, the low independence levels one is willing to endure, and whether or not a certain kind of activity will even be attempted (p. 91)

Negative attitudes have a significant impact on an individual's willingness and effort to do mathematics, which also impacts their achievement; therefore, negative attitudes toward mathematics must be improved. Bekdemir (2010) stated, "some victims with negative experiences recall vividly a moment of extreme embarrassment that sometimes wiped out years of success in mathematics and created a deep hatred for the subject" (p. 313). Suppose similar situations take place with a student. In that case, the student could carry these experiences with them to higher grades and into their careers, which lowers their confidence and motivation leading to mathematics avoidance, failure, and ultimately MA (Bekdemir, 2010).

Whether individuals begin feeling math-anxious in elementary or high school due to their self-efficacy, parents, or teachers, the fact remains that a percentage of them have MA and have suffered some traumatic experiences that are the root cause of their MA. To sum up the onset of MA, Stoeher (2017) stated, MA "may arise in response to a range of experiences with mathematics, both enacted and imagined, across a lifetime" (p. 80) and is a commonly encountered state in all levels of education (Gresham, 2018). Some individuals with MA have thoughts and dreams about their mathematics experiences, impacting their imagination about teaching mathematics. MA is different and personal for each individual and can be triggered by an array of factors at any point in life. An act as simple as opening a mathematics textbook, entering a mathematics class, or reading a cash register receipt can trigger a negative emotional response for individuals who have MA (Maloney & Beilock, 2012).

Differential Impact of Mathematics Anxiety

The literature on MA indicated implications for teachers' instructional practices in mathematics, teachers' attitudes toward mathematics, and how MA affects their students (Hughes, 2016; Swars et al., 2006; Isiksal, 2009; Haciomeroglu 2013; Ashcraft, 2002; Sandt & O'Brien, 2017; Stoehr, 2017). Elementary teachers who experienced high MA levels tend to use more traditional teaching methods comprised of lectures and teaching basic skills instead of mathematical concepts (Swars et al., 2006). Teachers' with high MA spent more time on seatwork, whole-class instruction, and teacher-dominated instruction that fostered a dependent student atmosphere (Haciomeroglu, 2013; Swars et al., 2006). When it comes to mathematics instruction, teachers who are highly math-anxious devote less time to planning and fewer hours to mathematics activities (Haciomeroglu, 2013; Isiksal et al., 2009). High levels of MA can negatively impact the mathematics classroom environment in many ways, ultimately influencing teachers' mathematics instructional practices and students' mathematics achievement.

Many researchers report that females exhibit higher MA levels than males (Ashcraft, 2002; Eden et al., 2013; Gresham, 2018; Hembree, 1990; Jensen, 2018). According to Eden et al. (2013), 20% of the population suffers from MA. Based on this percentage, females comprise half of that population (Jensen, 2018). Since many of our elementary teachers are female, it is essential to focus on the negative implications that may follow for teachers and students with MA (Jensen, 2018).

Females' confidence and performance in mathematics are factors that contribute to their MA. Females who have, in the past, received lower than expected or below-average mathematics scores were inclined to have high levels of MA (Gresham, 2018). This instance can be understood through mastery experiences of *personal self-efficacy*. Suppose some female's mathematics performance is consistently below average. In that case, they might begin to doubt their ability to do well mathematically and assume that future mathematics performance will also be below average. Additionally, Geist (2010, as cited in Van der Sandt and O'Brien, 2017) found that "girls tend to feel less confident about their answers on tests and often express doubt about their performance in mathematics. Over time, girls' assessment of their enjoyment of mathematics falls much more drastically than boys" (p. 97).

A plethora of research about teachers' MA and how it might transfer to their students has been researched (Aslan, 2013; Bekdemir, 2010; Boyd et al., 2014; Furner & Berman, 2003; Gresham, 2018; Haciomeroglu, 2013; Hill, 2010; Hughes, 2016; Liu, 2008; Maloney & Beilock, 2012; Morton, 2018; Peker & Ertekin, 2011; Stoehr, 2017; Unlu et al., 2017; Wood, 1988). MA is said to be transmissible (Liu, 2008), and teachers who have MA can interfere with students' learning and frequently create MA in their students (Furner & Berman, 2003). This cycle can begin early and harm success in mathematics (Aslan, 2013). According to Gresham (2018), "teachers' negative perceptions regarding mathematics elevated their [MA]. Several teachers indicated that some of their teaching practices were not effective, which not only heightened their own mathematics anxiety but also have caused or contributed to students' [MA]" (p.103). Haciomeroglu (2014) argued that individuals who have higher MA levels inadvertently transfer their negative feelings about mathematics, mathematics avoidance, and fears to students as some MA relates to how an individual teaches mathematics. Similar situations commonly occurred at the elementary level through teachers' minimal understanding of and negative attitudes toward mathematics (Lui, 2008). Some elementary teachers' MA ultimately affected their students (Hughes, 2016; Swars et al., 2006; Maloney & Beilock, 2012; Peker & Ertekin, 2011; Furner & Berman, 2003; Aslan, 2013). Teachers' attitudes and beliefs when teaching mathematics can determine students' success in mathematics (Lui, 2008). A concern is that MA remained in some in-service elementary teachers who experienced MA as college students (Lui, 2008).

MA is a construct experienced by many teachers and has impacted their mathematical ability and their students' mathematics achievement. MA also influences teachers' ability to teach mathematics to their students, and this relationship is conceptualized as the construct of mathematics teaching self-efficacy.

Mathematics Teaching Self-Efficacy

There are such cases where an individual has a knowledge base and skill in an academic subject but may not have the confidence or feel comfortable teaching this information to others. This idea relates to the construct of teacher self-efficacy. Teacher self-efficacy beliefs can be associated with teachers' instructional behavior, performance (Holzberger, Phillip, & Kunter, 2013), and students' achievement (Nurlu, 2015). Further, teacher self-efficacy directly impacts instructional practices, how teachers teach lessons, and the classroom atmosphere (Unlu & Ertekin, 2013). Teacher self-efficacy is frequently a subject matter-specific construct because a teacher may be comfortable teaching a specific academic subject. Still, this comfortableness may not necessarily translate to other academic subjects. Self-efficacy beliefs are important in teaching mathematics effectively; therefore, this study will examine more specifically mathematics teaching self-efficacy. Individuals may be very confident about their mathematics knowledge, but they become nervous, feel uncomfortable, or experience tension when teaching others mathematics (Brown et al., 2011). According to Franks (2017),

> while it is readily accepted that subject matter knowledge impacts teacher effectiveness, math teacher self-efficacy is an indicator of math teacher effectiveness and, therefore, a variable to strengthen and develop effective math teachers (p. 31).

Therefore, it is necessary to examine in-service elementary teachers MTSE to investigate their ability to teach mathematics to their students effectively.

Mathematics Teaching Self-Efficacy Defined

MTSE has been defined as a teacher's belief in their ability to teach mathematics based on their training or their experience in developing strategies to help students overcome barriers in their mathematics learning (Franks, 2017). Zuya et al. (2016) added that MTSE goes further than having professional knowledge and skills related to mathematics but can put said knowledge and skills into action. For this study's purposes, MTSE will be defined as a teacher's confidence in executing the necessary knowledge and skills to educate students in mathematics effectively.

According to Zuya et al. (2016), teachers who have high MTSE utilize their professional knowledge and skills successfully, while teachers who have low MTSE might restrain their professional knowledge and skills, ultimately affecting students' learning. A teacher's MTSE impacts students' learning by their selection of instructional methods and the classroom environment. A teacher who has high MTSE is more likely to use a variety of instructional strategies, try new and challenging instructional techniques, implement inquiry-based learning and student-centered teaching strategies. In contrast, a teacher with low MTSE primarily executes direct instruction and is over-dependent on the textbook (Swars et al., 2006). A teacher's critical asset with high MTSE is their effort to improve their teaching methods and experiment with instructional materials (Gresham, 2009). Ultimately, students' mathematics learning is either positively or negatively affected by a teacher's high or low MTSE. MTSE is essentially how teachers positively influence their students to advance in mathematics, decrease mathematics anxiety, and change their mathematics beliefs (Zuya et al., 2016).

Mathematics Anxiety and Mathematics Teaching Self-Efficacy

A literature review concluded that preservice teachers' MTSE was negatively influenced by their past experiences with mathematics and mathematics-related fears (Swars et al., 2006; Gresham, 2009). The mathematics experiences and fears of teachers were conceived to be caused by MA. Therefore, there is a link between MA and MTSE (Swars et al., 2006; Gresham, 2009; Unlu, 2017). Unlu et al.'s (2017) study determined a negative linear correlation between MA and MTSE. Franks (2017) study confirmed a p0ositive correlation between MA and MTSE. The majority of studies inferred that low MA teachers generally have high MTSE and high MA teachers typically have low MTSE. Teachers who had lower MA levels most likely had stronger beliefs in their abilities and skills to teach mathematics effectively. Teachers who had higher MA levels were more likely to have weak beliefs in their abilities and skills to teach mathematics effectively (Swars et al., 2006). To further explain this relationship, Gresham's (2009) study revealed two highly math-anxious elementary teachers who were not confident in their ability to teach mathematics effectively. These individuals struggled to develop their mathematics lesson plans, teach those lessons, and understand the mathematics content. According to Unlu et al. (2017), teachers who experience high MA levels did not appreciate teaching mathematics thus will not be effective in teaching mathematics. Knowing this information leads to an interest in researching in-service elementary teachers MA and MTSE to understand better how teachers plan for and teach mathematics to students.

Virtual Mathematics Instruction

Teachers have many things to consider when transitioning their face-to-face instruction to a virtual environment. In a virtual environment, teachers should consider more than merely delivering mathematics content electronically. Teachers should modify mathematics content for a virtual environment and technology to be delivered (Oliver, 2010). In the transition from face-to-face instruction to virtual instruction, modifications to mathematics content should not be undermined and include rich learning tasks that help develop mathematics concepts (Gadanidis et al., 2002). Virtual mathematics learning should focus on mathematics problem solving and the study of mathematics relationships; therefore, virtual activities should provide interactive exploration-supported mathematics experiences (Gadanidis et al., 2002). Although it can be challenging to incorporate group work in a virtual setting, this social interaction using technology is an essential component used in online learning (Gadanidis et al., 2002; Gedeborg, 2016).

Since virtual teaching and learning can look different from face-to-face classroom practices, the outcomes should be the same with students understanding and applying mathematics successfully (Gadanidis et al., 2002). An ideal way to ensure students understand and apply mathematics with success is to build social interaction opportunities using online technology tools that support mathematics exploration and discussions (Gadanidis et al., 2002; Gedeborg, 2016).

Mathematics Instruction in Urban Settings

Schools in urban communities are faced with many challenges. According to Corkin, Ekmekci, and Papakonstantinou (2015), students in greater need of effective instruction are economically disadvantaged. They are inclined to perform at lower rates on achievement tests than their more affluent peers. Urban communities often balance district-level requirements, school community circumstances, and students' home and community realities, which are different from suburban districts (McKinney, Chappell, Berry & Hickman, 2009). Low-income and minority children are at particular risk for underachievement in mathematics (Claessens & Engel, 2013). With such circumstances as these, it is necessary to have effective mathematics teachers in urban districts. Effective teachers can disrupt the pattern for students of color earning scores lower than their White peers in all mathematics content areas (McKinney, Berry, & Jackson, 2007). To unpack this concern, examining the instructional practices used by teachers in urban settings follows this section.

It is imperative to examine elementary teachers' instructional practices in urban settings because mathematical teaching methodologies play a significant role in student performance. The urban context is essential to explore since the literature speaks of restricted mathematics opportunities regarding curriculum and instruction for students in urban schools (McKinney et al., 2009). According to McKinney et al. (2007, 2009) and Berry et al. (2015), teacher-led instruction is the most common instructional methodology used in urban classrooms. The curriculum adhered to a fixed sequence using pacing guides focused on practicing basic skills without including problem-solving and reasoning, and teachers' opportunities to create and personalize curriculum are diminished (McKinney et al., 2009). Further, instruction is prescribed and repetitive with minimal emphasis on conceptual understanding (Berry et al., 2015).

Mathematics teaching is carried out by separating procedures from students' thinking, focusing on one strategy for obtaining a solution, and evaluating students' performance based on procedures instead of explanations (Battey & Neal, 2018).

While teacher-led instruction was observed in McKinney et al.'s (2009) study, a small percentage of teachers used a constructivist approach to teaching. A constructivist approach to mathematics instruction is student-centered and hands-on, where mathematical knowledge is constructed through student and teacher interactions (McKinney et al., 2007). With this method of mathematics instruction, students have an active role in developing a mathematics understanding on their own, and manipulatives play a vital role in helping students develop a conceptual understanding of mathematics. To produce more significant gains in mathematics performance, mathematics instruction should help students make sense of mathematics using manipulatives instead of instruction that does not use manipulatives (McKinney et al., 2007). Nonetheless, a constructivist approach to instruction presents challenges for ethnic minority teachers. Many find it challenging to integrate non-traditional, constructivist approaches in their instruction because they believe that mathematics instruction should focus on memorization and procedural skills (Corkin et al., 2015).

No one specific method of instruction or practice can be placed above the other for fostering mathematics learning. Hands-on and inquiry-based lessons have been documented as beneficial when creating opportunities for students to make sense of mathematics concepts (McKinney et al., 2009; Battey & Neal, 2018). To improve students' mathematics achievement in urban schools, teachers of mathematics should create and implement teaching strategies to increase students' learning capabilities (McKinney et al., 2009). Teachers who effectively teach mathematics can enhance students' mathematical performance in urban settings (McKinney, Bol, & Berube, 2010).

Teachers' mathematics instructional practices should include various strategies that engage students in learning, making sense of, and understanding mathematics to excite them for further exploration; otherwise, unsupportive creative thinking may cause MA (Bekdemir, 2010). mathematics instruction should not be carried out using methods such as assigning the same work to everyone, teaching the textbook problem by problem, and insisting on only one problem-solving strategy (Gresham, 2018). However, mathematics instruction should adhere to reform-oriented and inquiry-based instruction, which is more effective for students of color in the United States (Battey & Neal, 2018). Reform-oriented instruction encompasses mathematical communication and collaborative work (NCTM, 2000). Students are allowed to talk about and work with others on task to make sense of mathematics.

Recognizing that students of color need access to quality mathematics instruction is essential to improving their mathematics understanding and increasing their mathematics performance. One avenue to address this concern was researching in-service elementary teachers MA, MTSE, and virtual mathematics instructional practices, namely lesson planning and implementation.

Mathematics Education and Mathematics Instructional Methods

Mathematics performance of students is, in part, a result of the experiences they have with teachers in the classroom. The mathematical understanding students obtain: their problem-solving abilities, confidence in, and dispositions toward mathematics are formed by the teaching they receive at the school (NCTM, 2000). To improve mathematics education for all students, effective mathematics teaching in all classrooms is necessary. Principles and Standards of School

Mathematics (PSSM) noted that “teachers must know and understand deeply the mathematics they are teaching and be able to draw on that knowledge with flexibility in their teaching task. [and] Be skilled in choosing from and using a variety of pedagogical and assessment strategies (NCTM, 2000, p. 17).

Teaching mathematics is complex. One of the complexities is balancing purposefully designed classroom lessons with the continual decision-making between teachers and students during instruction. This takes place through unexpected discoveries or challenges that lead through uncharted territories (NCTM, 2000). Effective mathematics teaching is evident when interesting mathematics tasks are used to introduce important mathematical ideas that engage and challenge students intellectually, promoting curiosity, drawing them into the mathematics. The types of mathematics tasks designed by teachers relate to students' real-world experiences that are intriguing, challenging, and can be approached using multiple strategies (NCTM, 2000). Effective mathematics teaching does not solely rely on meaningful tasks. It depends on how teachers highlight certain aspects of tasks, organize student work, pose challenging questions, and support students through facilitation rather than dominating their thinking process, eliminating critical challenges.

Elementary teachers have an important role in educating students in mathematics and serve as role models. For this reason, it is expected that elementary teachers will be competent at mathematical skills, have a deep understanding of mathematics, and be able to effectively teach mathematics to students so they will be successful in mathematics (Boyd et al., 2014). Yet, this is uncommon for preservice teachers with high MA levels who lack confidence in their abilities to teach elementary mathematics effectively; moreover, their views on teaching and learning affect how and what they teach students (Haciomeroglu, 2014). According to McKinney et al. (2009),

> if the United States is to compete internationally, teachers need to facilitate all students' learning of important mathematics to promote construction of mathematical meaning [and] the most direct route to improving mathematics achievement for all students is through better mathematics teaching (p. 282,278)

To improve student mathematics performance and learning, elementary teachers should reflect on their mathematics skills and understanding while focusing their mathematics instruction on meaningful mathematics concepts. "Teachers must help students come to view mathematics not as an isolated set of rules to be memorized, but as the connection of ideas, mathematical domains, and concepts" (Stutton & Kruger, 2002, p. 36). In helping students make mathematical connections, teachers can consider different forms of mathematics pedagogy.

Two dominant forms of pedagogy are teacher-led instruction and student-oriented instruction. Teachers' effectiveness in ensuring optimal mathematics learning was divided between parents' prevailing cultural beliefs, some educators, and national mathematics reformers (NCTM, 2014). According to the Principles to Actions (NCTM, 2014), parents and some educators were convinced that students should be taught the same way those parents and teachers were taught—memorizing facts, formulas, and procedures with repetition. However, NCTM argued that mathematical lessons should focus on student engagement—students solving and discussing mathematical tasks that promote reasoning and problem-solving skills (NCTM, 2014). Hence, I will review teacher-led and student-oriented instruction literature because many teachers predominately use teacher-led instruction, although mathematics reformers advocate for student-oriented instruction.

Teacher-Led Instruction

Teacher-led instruction was classified as direct instruction, behaviorist teaching, traditional practices, and teacher-oriented instruction. Mercer et al. (1996, as cited in Van der Sandt and O'Brien, 2017) defined direct instruction as "instruction in which the teacher serves as the primary provider of knowledge and explanations, presenting skills and concepts . . . in a clear and direct fashion that promotes student mastery" (p. 99). Levine (1993) stated that a teacher-oriented method reflects "instrumental understanding which presents a view of mathematics as a finite domain of facts and rules with teacher or text as both its source and transmitter" (p.4). Combining these definitions, teacher-led instruction is a practice in which the teacher dominates the lesson with basic facts and rules and is viewed as the primary point of knowledge. Teacher-dominated activities are popular in American classrooms, concerned with explaining and lecturing, leading to learning by imitation (Cooney, Sanchez & Ice, 2000).

Reformers have insisted that instructional methods move from learning by imitation and toward student mathematics understanding that is more conceptually based on engaging students in solving and discussing mathematical concepts through problem-solving and reasoning (NCTM, 2014). Teachers who use learning by imitation when teaching primarily spend more time on seatwork, whole-class instruction, rote memorization of algorithms, cover fewer mathematics concepts, and neglect to consider their students learning styles (Bekdemir, 2010). One of the concerns that mathematics reformers had related to students learning mathematics is memorizing facts and procedures without understanding and connecting mathematics to their everyday lives (NCTM, 2000). Therefore, teachers who primarily teach mathematics using imitation and dedicating more time to whole-class instruction could consider various teaching methods.

Some elementary teachers with MA and poor attitudes toward mathematics tend to rely on traditional instructional styles that include teaching skills and fewer concepts, seatwork, and whole group instruction. They spend less time correcting homework; provide minimal small group sessions; accept fewer student questions; and, provide fewer experiences with problem-solving, interactive games, cognitive thought processes, and mathematics reasoning (Gresham, 2018; Hadley & Dorward, 2011; Hughes, 2016, Iyer & Wang, 2013). In such cases, elementary teachers need to understand the mathematics curriculum and knowledge of effective nontraditional methods to teach mathematics effectively to students (Gresham, 2018). The teaching practices previously mentioned go against those recommended by NCTM, which advocates for student-centered instruction that nurtures social collaboration and peer support through cooperative learning.

According to NCTM's Principles to Actions document, eight mathematics teaching practices are recommended as a framework for learning mathematics to strengthen teaching. These teaching practices consist of a) establishing mathematics goals to focus learning, b) implementing task that promotes reasoning and problem-solving, c) use and connect mathematical representations, d) facilitate meaningful mathematical discourse, e) pose purposeful questions, f) build procedural fluency from conceptual understanding, g) support productive struggle in learning mathematics and h) elicit and use evidence of student thinking learning (NCTM, 2014, p. 10). These practices are essential skills necessary to promote deep mathematics understanding and are not frequently adhered to when teacher-led instruction is the primary instruction method.

According to McKinney et al.'s (2009) study, 83% of urban elementary teachers frequently used direct instruction, while only 46% used alternative approaches such as hands-on learning activities. Traditional methods are successful for some students; the problem is that many students are forgotten about when lectures, individual seatwork, and minimal board instruction are the primary instructional delivery methods (McKinney et al., 2009). In such cases, teachers teach the same way they were taught (McKinney et al., 2009). An alternative to teacher-led instruction is student-oriented instruction, and this method is closely aligned to the eight mathematics teaching practices outlined in the Principles to Actions document.

Student-Oriented Instruction

In contrast to teacher-led instruction, student-oriented instruction reflects a relational understanding that views mathematics as a combination of dynamic concepts and procedures that are actively learned and become resources for future situations (Levine, 1993). This form of instruction was also characterized as alternative practices that promote participatory-and inquiry-motivated practices that emphasize reasoning and problem-solving skills and student discourse (Berry et al., 2009), leading to a conceptual understanding of math material significant to teaching goals (Levine, 1993). Instruction of this sort resembles the constructivist model for teaching, which focuses on connecting new knowledge to students' prior knowledge and other curricular areas. Muijs and Reynolds (2002) stated that this method of teaching "cognitively challeng[es] students in order to allow them to develop their thinking skills, allowing student input into the lesson, using real life materials, examples and contexts and correcting misconceptions" (p. 27). Students taught using constructivist instructional methods are inclined to develop a conceptual understanding of various mathematical concepts (McKinney et al., 2009; Berry et al., 2009).

Student-oriented instruction was summarized as instruction that allows students to explore, reason, make mistakes, and apply prior knowledge to new knowledge and the real-world context in many engaging forms. Student-oriented instruction consists of small group work, student-led lessons and discussions, manipulatives and interactive games, and activities (Gresham, 2018; Nelson & Sassi, 2007; Muijs & Reynolds, 2002). According to Stutton and Krueger (2002), effective student-oriented instruction is a combination of "guided questioning with a set of experiences and lessons chosen to build upon the experiences and level of understanding that students already have" (p.36). Also, tasks are provided with multiple entry points using various tools and representations that reach high levels of cognitive demand (NCTM, 2014). Berry et al. (2009) advised that students exposed to alternative approaches to mathematics teaching have access to teaching practices guaranteed to be effective and successful, which allows them to be actively involved in the lesson and motivated to see major concepts and big ideas.

Student-oriented instruction provides students opportunities to investigate mathematical concepts through interesting and challenging mathematics problems made up of meaningful mathematics ideas. Students are encouraged to use various approaches and strategies to make sense of and solve mathematical tasks (NCTM, 2014). Also, students use multiple tools as manipulatives, calculators, and computers to explore mathematics concepts while making sense of these concepts in groups and individually (Stutton & Kruger, 2002). The purpose of manipulatives is for students to explore, represent, and communicate mathematical ideas while understanding mathematics and making connections (Nelson & Sassi, 2007; Stutton & Krueger, 2002). These tools are not intended to inhibit students' learning; instead, they offer students the chance to make connections by representing their thinking during problem-solving. While these factors contribute to an ideal setting for student-oriented instruction, it is worth noting that some factors must be well thought out during lesson planning and instruction. Nelson and Sassi (2007) contended "enumeration of problem-solving strategies without discussion of their accuracy or effectiveness can deprive students of the opportunity for rigorous mathematical thinking" (p. 55). Hence, it is not enough to present students with opportunities to learn mathematics without thoughtful lesson planning and having classroom discussions about how these tools and learning opportunities can enhance their mathematical understanding.

During student-oriented instruction, students can reflect and gain a deep understanding of mathematics (McKinney et al., 2009). The teacher has more of a facilitator role in that he/she actively listens to students, clarifies misunderstandings, and probes student thinking. Nontraditional instruction methods are student-centered, promote conceptual understanding and mathematical processes, and provide opportunities for discovery by allowing multiple paths to arrive at the correct answer (McKinney et al., 2009) to extend students' knowledge base.

Another vital element of student-oriented instruction is student questioning and feedback. Elementary teachers need to include a mixture of high and low-level questions in their lessons that require open-ended answers, not those that can be answered with yes or no but offer students the chance to explain and justify their mathematics thinking (Muijs & Reynolds, 2002; Nelson & Sassi, 2007). Low-level questions seek to test students' ability to recall facts and details without necessarily reaching for understanding or relating to the context. High-level questions promote learning transfer and knowledge within the context and among relationships. According to the Principles to Actions (NCTM, 2014) document, "purposeful questions allow teachers to discern what students know and adapt lessons to meet varied levels of understanding, help students make important mathematical connections, and support students posing their own questions" (p. 35). Wait time for questioning is also important, 3 secs for low-level questions and a bit longer for high-level questions based on the difficulty of questions and students' ability levels to explain

(Muijs & Reynolds, 2002). Open-ended questions "often require students to explain their thinking and thus allow teachers to gain insights into their learning styles, the 'holes' in their understanding, the language they use to describe mathematical ideas, and their interpretations of mathematical situations" (Moon & Schulman, 1995 as cited in Cooney et al., 2000, p. 10). Muijs and Reynolds (2002) suggested that feedback be professional but positive, acknowledging correct answers and encouragement when incorrect answers are given before moving to other students. When students are engaged in discussions, they can make better sense of ideas, create and demonstrate understanding, and reflect on their mathematics thinking. These instances are when maximum learning takes place (Stutton & Krueger, 2002).

Lastly, a critical component of student-oriented instruction is problem-based instruction. Problem-based instruction is a method of instruction where students can learn mathematics by solving rich mathematical tasks (King, 2019). Problem-solving was included in the common core state standards as one of the criteria for mathematical practice. The first standard in the mathematical practices is for students to make sense of problems and persevere in solving them. Problem-solving is the process of engaging in a task in which the solution is unknown at the beginning of that task (NCTM, 2000) and one in which students do not perceive there is one correct method to a solution (King, 2019).

Through problem-solving in mathematics, "students should acquire ways of thinking, habits of persistence, and curiosity, and confidence in unfamiliar situations that will serve them well outside the mathematics classroom" (NCTM, 2000, p. 52). Students are afforded opportunities to think, persist, and engage their curiosity and confidence mathematically when teachers provide rich mathematics problems and tasks. A teacher's role is to analyze and adapt problems, foresee students' questions, and determine if specific problems will assist in promoting their mathematical goals for the class (NCTM, 2000). According to a study conducted by Inglis and Miller (2011), through problem-based instruction, students began to understand how their new mathematics skills would be helpful in other subject areas and how mathematics is a skill used in everyday life. Inglis and Miller concluded that teachers play an integral part in encouraging students to attempt different problem-solving strategies, find solutions using various approaches, and be okay with getting the wrong answer.

Further, when solving problems, students should understand what is being asked of them, what should be figured out, the information needed to find the solution, and how to approach it (Inglis & Miller, 2011). Overall, problem-based instruction provides students the chance to develop, grapple with, and solve complex problems that demand a great deal of effort. Students should be encouraged to reflect on their thinking (NCTM, 2000).

Thus far, some teachers teach in a traditional style as teacher-led instruction, and some have taken a constructivist teaching style as student-oriented instruction. Despite the variety of instructional methods in mathematics, traditional pedagogical practices continue to lead mathematics education (McKinney et al., 2009). Mathematics instruction can be carried out in many different ways; there is no one-size-fits-all when it comes to learning. Elementary teachers should use various instructional strategies that engage students in exploring mathematics through inquiry-based activities that allow them to think, reason, and justify individually and in small groups. Students bring knowledge to the classroom, and teachers can build on those knowledge bases by asking open-ended questions, providing students positive feedback, and encourage students to reflect on their thinking to challenge them to grow mathematically. Referencing the PSSM document, mathematics makes more sense and is easier to remember and to apply when students connect new knowledge to existing knowledge in meaningful ways (NCTM, 2000).

Effective mathematics teaching happens when teachers know their students' strengths and needs, interests, backgrounds, and preferences and incorporate these aspects into their instruction, challenging students to meet high expectations (Stutton & Krueger, 2002).

Conclusion

Mathematics performance of students, especially students of color, in the United States, needs improvement. Results from the Nation's Report card and NAEP demonstrate that students in grades fourth, eighth, and twelfth were not performing at the proficient mathematics level. Teachers experience challenges transitioning their face-to-face mathematics instruction to a virtual setting. Additionally, mathematics classrooms in urban schools are presented with many challenges that impact the mathematics instruction students receive. Therefore, there is a need for high quality mathematics instruction to ensure there are improvements in students mathematics performance. One area to consider for these situations are in-service elementary teachers MA, MTSE, and their virtual mathematics instructional practices since mathematics performance is affected by MA.

MA is a prevalent phenomenon for both preservice and in-service elementary teachers. MA was defined as expressing the general lack of comfort that an individual might feel when thinking about, performing, and teaching mathematics. Elementary preservice and in-service teachers have both been identified as having varying levels of MA. The literature explained that some cases of MA had impacted these teachers' instructional practices (Haciomeroglu, 2013; Isiksal et al., 2009; Swars et al., 2006), and MA was passed to their students (Aslan, 2013; Bekdemir, 2010; Boyd et al., 2014; Gresham, 2018; Haciomeroglu, 2013; Hill, 2010; Hughes, 2016; Liu, 2008; Maloney & Beilock, 2012; Morton, 2018; Peker & Ertekin, 2011; Stoehr, 2017;

Unlu et al., 2017; Wood, 1988;). MA was more prevalent in females than males (Ashcraft, 2002; Gresham, 2018; Hembree, 1990; Jensen, 2018).

Many factors contribute to an individuals' MA and can be classified into three categories: environmental factors, intellectual factors, and personal factors. Environmental factors appeared to have the most significant impact on an individuals' MA (Hembree, 1990) due to teachers' opinions about students' abilities, teachers' attitudes toward mathematics, parental attitudes toward mathematics, and non-supportive class environments. The literature reviewed established that the onset of MA generally took place in elementary grades (Bekdemir, 2010; Isiksal et al., 2009; Maloney & Beilock, 2012; Morton, 2018; Smith, 2010), while some pinpoint secondary grades (Brown et al., 2011). Elementary teachers who exhibited MA taught in a more traditional style through lectures, whole group instruction, less time on mathematical concepts, and limited student engagement. The literature established that preservice teachers who were math-anxious had greater chances of becoming teachers who lacked confidence in their mathematics abilities, had negative attitudes toward mathematics, and taught in ways that created MA in their students (Bekdemir, 2010).

Some teachers are confident in their mathematics knowledge however are not confident in teaching mathematics to students (Peker & Ertekin, 2011; Yazici & Ertekin, 2011). Such teachers may have low MTSE. MTSE was defined as a teacher's confidence in executing the necessary knowledge and skills to educate students in mathematics effectively. Teachers who have low MTSE possibly adhere to direct instruction relying on the textbook. In contrast, teachers with high MTSE are more likely to use a wide range of instructional methods and implement student-centered instructional strategies. Butler (2010, as cited in Franks, 2017) stated, "[MTSE] is an indicator of math teacher effectiveness and therefore a variable to strengthen and develop effective math teachers" (p. 31). Therefore, it is imperative to investigate in-service elementary teachers' beliefs about their ability to teach mathematics and improve their mathematics instruction.

According to the literature, elementary teachers should have mathematical competence, mathematics content knowledge, and the ability to effectively teach mathematics to their students (Boyd et al., 2014). There were two teaching methods in the literature enacted by elementary teachers. Teacher-led instruction is most commonly used in many elementary classrooms and had mixed reviews on its effectiveness in ensuring students' mathematics achievement and success. On the other hand, student-centered instruction was recommended by many researchers who believed that a constructivist approach to instruction allows students to be independent thinkers who can explore mathematics through inquiry-based learning with the use of mathematical tools (Cooney et al., 2000; Gresham, 2018; NCTM, 2000; Nelson & Sassi, 2007; McKinney et al., 2009; Stutton & Krueger, 2002). Utilizing either method of instruction has benefits; nonetheless, student oriented-instruction helps students explore mathematics in meaningful ways because they can connect new knowledge to existing knowledge (NCTM, 2000). Ultimately, mathematics instruction should be centered on the process and problem-solving rather than solely computation and using one method to solve problems (Furner & Berman, 2003).

The literature reviewed for this study suggested that elementary teachers who have MA need to consider their mathematics skills and abilities to become effective mathematics teachers. Their level of MTSE speaks to the type of mathematics instructional strategies they might typically use. These components: mathematics skills, abilities, and mathematics content knowledge, influence teachers' ability to learn mathematical concepts and effectively teach mathematics to their students (Haciomeroglu, 2013). Teachers who lack mathematical knowledge are less likely to present material clearly and provide error-free content (Hill, 2010).

Together, the studies reviewed suggest that MA and MTSE are two constructs that impact elementary teachers' mathematics instructional practices. This study's assumption runs parallel to the literature reviewed; the MA and MTSE of elementary teachers are related to their mathematics instructional practices. However, it is important to note that teachers' MA and MTSE may not fall in line with their instructional practices as outside influences of the school context may increase in-service teachers' MA and decrease their MTSE. Hence, impacting their mathematics instructional practices. According to Ernest (1999, as cited in Hughes, 2016)

> there is a great disparity between espoused and enacted models of teaching and learning mathematics. Although prospective teachers may have been taught to adopt a reformed practice during their teacher-training years, the practicing teachers are subject to the constraints and contingencies of the school context once they enter the classroom (p. 85).

Despite the amount of research on MA, MTSE, and preservice teachers' instructional practices independently, limited research that examined the relationships between these constructs and in-service elementary teachers has been documented. Few studies link both MA and MTSE to elementary teachers' mathematics instructional practices (Swars et al., 2006; Gresham, 2009; Franks, 2017).

The results of this study will add to the current research on MA and MTSE to illuminate relationships with teachers' virtual mathematics instructional practices in elementary classrooms. These results can help bring to light the relationship between these constructs. Thus, this research can better inform teacher preparation programs, elevate elementary teachers' mathematics instruction, improve students' mathematics performance, and help educational leaders help teachers work more effectively when teaching mathematics.

Chapter 3
Methods

A qualitative comparative case study (Goodrick, 2014) was chosen for this study utilizing an explanatory design. When investigating a phenomenon in its real-life context, a case study approach is most appropriate (Yin, 2014). An explanatory case study explains how or why a sequence of events took place (Yin, 2014). The phenomenon under investigation in this study was the relationship between MA and MTSE in in-service elementary teachers' virtual mathematics instructional practices. An explanatory case study helped to explain how teachers described their MA and MTSE and the influence these constructs had on their virtual mathematics teaching practices.

Research Design

A comparative case study consists of six steps:

1) Define the study's research questions and purpose to determine if a comparative case study design is appropriate.
2) Identify initial theories or propositions to direct the comparative case study and draw on the theory.
3) Define the type of cases to be included and the process of how it will be carried out.
4) Identify how data will be collected, analyzed, and synthesized within and across cases.
5) Consider and test alternative explanations for the outcomes.
6) Report findings (Goodrich, 2014).

A comparative case study design was conducted to explain how MA and MTSE were portrayed in in-service elementary teachers and how these constructs influenced their virtual mathematics instructional practices. The cases for the study were two teachers that taught 4th and 5th-grade and used a reform mathematics curriculum. The cases were conducted concurrently and compared across cases. According to Goodrich (2014), cross-case analysis involves a type of pattern matching where two or more patterns are compared between the cases to determine similarities or differences to explain observed processes or behaviors. To assist with the explanatory design, I employed the theoretical self-efficacy framework.

Self-efficacy (Bandura, 1977; 1986;1989; 1995) theory as a lens helped the researcher focus on urban in-service elementary teachers' past experiences learning mathematics and how those experiences may have shaped their mathematics anxiety and mathematics teaching self-efficacy. Self-efficacy for this study was defined as a self-perceived judgment about one's capability to perform a task. This study explored potential relationships between MA and MTSE in urban in-service elementary teachers' virtual mathematics instructional practices. Furthermore, the virtual instructional methods and tasks these teachers used to engage students in mathematical learning were explored. This chapter provides a description of the participants, research design, data collection, instrumentation, and procedures.

Research Questions

To understand the relationship between mathematics anxiety and mathematics teaching self-efficacy and urban in-service elementary teachers' virtual mathematics instructional practices, the driving questions for this study were:

1. How are MA and MTSE characterized in in-service elementary teachers?
2. How do virtual mathematics instructional practices vary among in-service elementary teachers with different profiles of MA and MTSE?

Participant Recruitment

The case study was conducted on a Midwestern urban school district targeting four elementary schools and ten elementary teachers. I considered several factors in selecting the cases. First, this study was limited to in-service elementary teachers who taught 4^{th} and 5^{th} grade and had at least three years of teaching experience. Grades 4^{th} and 5^{th} were chosen because they cover abstract mathematical concepts foundational to understanding higher-level mathematics concepts. In 4^{th} and 5^{th} grade, learners are exposed to mathematical domains and standards that call for students to represent, solve, and interpret mathematics concepts preparing them for higher-level mathematics subjects. Research has shown that teachers who experience higher MA levels find it challenging to teach third through fifth grade and decide to teach first or second grade (Gresham, 2018). As grade levels increase, mathematical concepts become more complex; therefore, studying teachers who taught 4^{th} and 5^{th}-grade informed how effective they were teaching students' mathematical concepts.

Second, teachers had to teach mathematics as part of their teaching assignment. A third factor considered for case selection was teachers had to use a reformed curriculum for teaching mathematics. A reformed curriculum helps students make connections and sense of mathematics through explorations, projects, and cooperative groups. A reformed curriculum also adheres to principles laid out by NCTM and the Common Core State Standards for Mathematics. By comparative case study design, I needed at least two teachers (Yin, 2014), preferably from different schools, to agree to participate.

A research request form was completed, and then principals were contacted to grant access to their teachers' email addresses. A virtual meeting with each principal took place to discuss the study and the benefits of participation. Next, teachers were emailed the following documents: an invitation letter to participate in the study and a consent form. The invitation letter[1] included a description of the study, an explanation of the topic, and the necessary information in an Institutional Review Board (IRB) document. Prior to conducting any aspect of this research, a request to my institution's IRB was made. Upon approval, the study ran in accordance with the standards and regulations stated by the IRB for the protection of human subjects.

The benefits of participation consisted of helping teachers realize the need for reflecting on their teaching practices, highlighting areas of strengths and areas of potential growth, preparing mathematics lessons, and implementing these lessons. Also, potentially identifying ideal topics for tailoring professional development individualized to teachers' mathematics instruction was beneficial.

Participants

Three teachers completed the AMAS and MTMSE surveys. All teachers taught 4th-grade, and one taught both 4th and 5th-grade mathematics only. One teacher did not respond to the request for participation in interviews; therefore, only two teachers participated in this research study's remaining stages. The two participants identified as white females who earned bachelor's degrees, lifetime teaching licenses, and taught for at least three years. Table 3.1 summarized their demographics in more detail.

Table 3.1

Teacher Demographics

[1] See appendix A

Name	*Race*	*Years Teaching*	*Years Teaching Math*	*Major*	*Certified Grades*	*Subjects Taught*
Lisa	White	6-10	10	Education	1 - 8	Language Arts Math Reading Science Social Students
Marie	White	3-5	4	Elementary Education	Pre-K-6	Math Science

The two participants taught in an urban school district that served approximately 5200 students; 72.5% were enrolled in the free/reduce lunch program. The ethnic diversity of the students was: 57% Hispanic, 31% Black, 8% White, and 4% Other. Students' mathematics performance in this school district was measured using the Forward Exam, which determined students' proficiency level in mathematics. In 2018-2019 approximately 25% of 4th graders scored proficient and advanced on the Forward Exam.

Instrumentation

The Abbreviated Mathematics Anxiety Rating Scale (AMAS) (Hopko, Mahadevan, Bare, & Hunt, 2003) was used to assess elementary teachers' MA levels. The Mathematics Teaching and Mathematics Self-Efficacy Survey (MTMSE) (Kahle, 2008) was used to evaluate their MTSE levels. A lesson plan evaluation rubric was designed to assess teachers' lesson plans. The Mathematical Classroom Observation Protocol for Practices (MCOP) (Gleason, Livers, & Zelkowski, 2015) was utilized to evaluate teachers' instructional practices. Lastly, a fraction simulation task was incorporated to assess teachers' approach to teaching a challenging mathematics concept (Fazio & Siegler, 2011).

Abbreviated Mathematics Anxiety Rating Scale

The AMAS survey was chosen to measure elementary teachers' MA. Further, elementary teachers were asked to complete a mathematics teaching self-efficacy survey. The AMAS is a 9 item Likert scale[2] survey developed by (Hopko et al., 2003). Internal consistency for the entire AMAS was α =0.9 and for the subscales Learning Math Anxiety (LMA) α=0.85 and Math Evaluation Anxiety (MEA) α=0.88. The subscales were designed to measure anxiety about the process of learning mathematics, LMA, and anxiety before, during, and after a mathematics testing situation, MEA (Hopko, 2003). Test-retest reliability for the entire survey was (r =0.85), and the subscales were LMA (r=0.78) and MEA (r=0.83) (Hopko et al., 2003). The validity of the AMAS was assessed through convergent and divergent validity. The subscales LMA and MEA were strongly correlated (r =0.62) and together strongly related to the total score (LMA, r=0.88; MEA, r=0.92). Since the subscales were strongly correlated and relate to the total score, it would not make sense to report the subscale scores. These subscales could measure similar variables associated with the construct of MA; therefore, the total scale score was used to report elementary teachers' MA.

The authors determined strong convergent validity between MARS-R and AMAS (r=0.85), AMASlma (r=0.70), and AMASmea (r=0.81). As it relates to divergent validity, Hopko et al. (2003) stated, "in general, moderate associations were obtained among the AMAS total and subscale scores, with other anxiety measures (r = .20-.54) indicating some level of divergent validity with these measures" (p. 180).

Mathematics Teaching and Mathematics Self-Efficacy Scale

The MTMSE was developed by Kahle (2008) using a combination of the Mathematics Self-Efficacy Scale Revised (Pajares & Kranzler, 1997) and the Mathematics Teaching Efficacy

[2] See Appendix B for AMAS

Beliefs Instrument (MTEBI) (Enochs, Smith & Huinker, 2000) to fit her study. MTMSE was divided into six parts, which assessed teacher mathematics self-efficacy (parts 1 and 3), teacher mathematics teaching self-efficacy (parts 2 and 4), conceptual and procedural teaching orientation (part 5), and demographic questions (part 6). For this study, only parts 2, 4-6 were used as those portions were more in line with questions that assess MTSE. Part 2 of her research was the first portion of the current study's scale, and parts four and five were combined to create the second portion of the scale for the present study; demographical information followed the second portion[3].

The mathematics teaching self-efficacy portion of MTMSE was created to include more mathematics content topics from the five NCTM content standards: number and operations, geometry, algebra, data analysis and probability, and measurement (Kahle, 2008). This portion of the instrument asked teachers to rate their confidence level in teaching several NCTM content standards topics as multiplication, fractions, and division, which are emphasized in elementary grades. The MTMSE was divided into two parts: part one consisted of 13 items on a 6-point Likert scale ranging from one (strongly disagree) to six (strongly agree). It asked questions such as—even if I try very hard, I will not teach mathematics as well as I will most subjects; I understand mathematics concepts well enough to be effective in teaching elementary mathematics. Part two consisted of 13 items on a 6-point Likert style 0scale ranging from one (not confident at all) to six (completely confident) that assess teachers' confidence in teaching mathematics content standard topics. The origins of the mathematics teaching self-efficacy were from the MTEBI, which had two subscales: the personal mathematics teaching efficacy subscale and the mathematics teaching outcome expectancy subscale. Only the questions from the personal mathematics teaching efficacy subscale were used in this current study because they

[3] See Appendix C for MTMSE Survey

related directly with MTSE as they assessed an individual's belief in their ability to teach effectively. The teaching outcome expectancy subscale questions were not used since those questions are directly related to a teacher's belief that student learning can be influenced by effective teaching (Enochs, Smith, & Huinker, 2000), which was not the aim of this study. According to Kahle (2008), "the personal mathematics teaching efficacy subscale in the original MTEBI showed a Cronbach's alpha coefficient of internal consistency of 0.88" (p. 71); therefore, this portion of the MTMSE was reliable for assessing teachers MTSE.

The conceptual and procedural teaching portion of MTMSE was selected because it assessed teachers' tendency to teach toward procedurally oriented teaching methods or conceptually oriented teaching methods. Teachers who have MA tend to teach more procedurally through traditional teaching methods focusing on basic skills rather than concepts, presenting mathematics exercises problem by problem (Gresham, 2018; Hughes, 2016; Iyer & Wang, 2013). Assessing the type of teaching method urban in-service elementary teachers use helped inform how they approached their mathematics instructional practices and their goals for student mathematical understanding. The research indicated that instructional methods to teach mathematics other than traditional approaches tend to develop a conceptual understanding of various mathematics concepts without losing basic arithmetic computational skills (McKinney et al., 2009). Therefore, utilizing an instrument that assessed whether elementary teachers used a procedural or conceptual approach to teaching was imperative to understand how they designed and implemented mathematics instruction.

According to Kahle (2008), the questions in the MTMSE were "inspired by Hiebert (1989), Skemp (1987), and numerous other researchers" (p.72). There were 12 items on a 6-point Likert style scale ranging from one (strongly disagree) to six (strongly agree). An example of a procedural question was, “I put more emphasis on getting the correct answer than on the process followed.” An example of a conceptual question was, “I frequently ask my students to explain *why* something works.” The questions in this portion of the MTMSE were written by Kahle (2008) and tested for construct validity using a panel of experts and field-tested (Kahle, 2008). It is worth noting that the author of the MTMSE also tested the instrument for face validity to ensure it measured mathematics teaching self-efficacy; she conducted a pilot study and tested for readability. According to Miller (2005, as cited in Kahle, 2008), “readability of the survey questions was desired to be no higher than an eighth-grade reading level as suggested as appropriate for elementary teachers” (p. 78). The readability of the MTMSE was calculated by Kahle (2008) using the Gunning fog index (Gunning, 1952) and resulted in an average readability of 7.75; therefore, it was determined to be appropriate for elementary teachers.

The demographics portion of the MTMSE solicited demographic information about the elementary teachers, such as years of teaching experiences, grade levels taught, most favored and unfavored elementary subjects to teach. It also included the NCTM content strand the teacher was most and least confident to teach.

The original MTMSE had 69 items divided into five parts, and the 6th part was not included in the item count as it covered demographic questions. Only parts two and four of the original MTMSE relate to the subscale: personal mathematics teaching efficacy, which was proven reliable to assess MTSE. For the current study, 38 items divided into two parts were used: mathematics teaching self-efficacy and procedural and conceptual teaching. The questions in those two parts assessed a teacher’s confidence in teaching mathematics in general and specific mathematics content standard topics, which ultimately considered a teacher’s MTSE. A third part, demographics, concluded the survey and consisted of twelve items.

Interview Protocols

Two interview protocols were used in this study: an initial teacher interview and a post-observation interview. The initial interview protocol consisted of 22 questions inspired by the AMAS and MTMSE surveys and interview protocols from the previous research literature (Swars et al., 2006; Kahle, 2008). The interview protocol was used to collect in-depth information on the teachers' past experiences learning mathematics and their perceptions about their skills, abilities, and confidence to teach mathematics and how MA may have affected these perceptions. The post-observation interview protocol consisted of eight equations based on teacher lesson plans and teacher observations. The post-observation interview protocol was used to gather detailed information about what was observed during teacher observations, teachers' experiences planning and teaching mathematics virtually, and general information teachers wished to share about their teaching practices.

Mathematical Classroom Observation Protocol for Practices (MCOP²)[4]

The MCOP² was a mathematics classroom observational instrument used in grades K–16 to measure the scope of alignment of a mathematics classroom with several standards set forth by prominent national mathematics organizations. This tool was specifically designed to measure mathematics classroom practices for teaching lessons that are goal-oriented toward conceptual understanding emphasizing three classroom components: student engagement, lesson design and implementation, and classroom culture and discourse. There were 16 items focused on mathematics classroom interactions between the teacher and students that promote conceptual understanding. The framework and language of the MCOP² were created using the Standards for Mathematical Practices and other instruments. The rubrics for the MCOP² items were created using scores on a 0, 1, 2, or 3 point scale through an iterative process that involved watching

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[4] See appendix E for MCOP² tool

classroom videos to determine detailed criteria for each level in the rubric referencing related literature for specific classroom interactions. A user guide resulted from this process with detailed descriptions that indicated the teacher and students' behaviors and characteristics in the classroom.

The MCOP^2 measured different teacher facilitation and student engagement factors using two subscales of nine items on each subscale (Gleason et al., 2015). For this study, only the items that assessed a teacher's lesson design and implementation were used. This component focused exclusively on the teacher as facilitator and how he/she guides student learning. The authors of this scale recommended that an observer attend an entire lesson to account for teacher design and structure of the lesson and student interactions. Also, the authors recommended three to six class observations to capture the teachers' mathematics practices and their typical class interactions with students (Gleason, Livers, & Zelkowski, 2017). Items in the teacher facilitation portion of the MCOP^2 were designed to measure the teacher's role as the individual who provides the lesson structure, guides tasks that are implemented during instruction, and classroom discourse. This portion asked an observer to focus on such aspects of the lesson as mathematical tasks with multiple entries to a solution and various solutions and if lessons detailed fundamental concepts of a subject to promote conceptual understanding (Gleason et al., 2015).

This tool was validated based on test content, internal structure, and response processes (Gleason et al., 2017). To validate the test content, an iterative process of expert surveys was used to clarify the test items and their descriptors and confirm if they measured the desired constructs of classroom interactions. The internal structure was validated when the test items and descriptors were modified from the test content validation process using a Horn parallel analysis and an exploratory factor analysis (Gleason et al., 2017). The Horn parallel analysis was a statistical method used to determine the number of components that should be kept when running an exploratory factor analysis. Using the exploratory factor analysis, applying a total raw score for each subscale was sufficient instead of scaled scores (Gleason et al., 2017). The first factor consisted of items that depend on students' actions; therefore, it was labeled student engagement (SE) and resulted in nine items with high internal consistency (Cronbach's alpha = 0.897). The second factor consisted of items that depend on the teacher's actions as a facilitator; therefore, it was labeled teacher facilitator (TF) and had high internal consistency (Cronbach's alpha = 0.85) (Gleason et al., 2017). The last step was to analyze the subscales using inter-rater reliability to show evidence based on response processes.

Inter-rater reliability of the MCOP^2 was analyzed using five different classroom videos. One video from each grade band, K–2, 3–5, 6–8, 9–12, and undergraduate grades, was chosen, with each rater evaluating the videos individually to develop a two-way model for the intraclass correlation (ICC) (Gleason et al., 2017). Five raters with varying mathematical backgrounds were given detailed descriptions of the items and the rubric before any observations. None of them received formal training on the tool's use. This practice was in line with future uses. A single-measures ICC was used since all raters evaluated the videos, and the instrument was designed to measure classrooms at the subscale level; therefore, subscale scores determined the ICC. Gleason et al. (2017) stated, "the interrater reliabilities are characterized by absolute agreement to allow comparison of the results from the protocol across studies" (p. 8). Thus, to assess the degree to which coders provided consistency in their classroom ratings for practices across subjects, each of the subscale totals and the overall instrument total was analyzed with a two-way mixed absolute agreement ICC. Results of the single measure ICC for the SE subscale

(0.669) and TF subscale (0.616) fell within the good fit range, which indicated a high degree of agreement between coders on both subscales (Gleason et al., 2017).

Data Collection Procedures

Once teachers agreed to participate by submitting their consent form, I emailed teachers a link to the surveys' electronic version. Table 3.2 details the data collection timeline. Teachers were given one week to complete the surveys. A follow-up email was sent after one week as a reminder to complete surveys. Participants completed both surveys within three weeks. Overall scores from these surveys were used to assess teachers' MA and MTSE levels.

Table 3.2

Data Collection/Analysis Activities

	Week 1	Week 2	Week 3	Week 4/5	Week 6	Week 7/8	Week 9	Week 11	Week 16	Week 19
MA and MTSE Surveys	Administered Surveys Participants begin to complete surveys	Participants complete surveys	Followed-Up on incomplete Surveys	Analyzed surveys and collect lesson plans	Analyzed lesson plans using Lesson plan rubric					
Interviews (45mins)				Scheduled Teacher interviews		Week 7: Interviewed Lisa Week 8: Interviewed Marie	Analyzed interviews			
Virtual Classroom Observations (1 hour)						Week 7: Lisa 1st Observation Week 8: Lisa 2nd and 3rd Observations		Week 11: Marie 1st-3rd Observations		
Post Observation Interviews (30mins)						Week 8: Lisa Post-Observation Interview	Analyzed Post Observation Interview	Week 11: Marie Post-Observation Interview Analyzed Post-Observation Interview		
Fraction Simulation Task (20mins)									Marie Fraction Task Simulation Analyzed Task	Lisa Fraction Task Simulation Analyzed Task

Note: Weeks 10, 12-15 were observed for Thanksgiving and Christmas Break. Weeks 17 and 18 were used for other aspects of the research study.

The second step of data collection consisted of scheduling interviews and collecting lesson plans. Each teacher was asked to submit lesson plans for three lessons. The ultimate goal of collecting mathematics lesson plans was to examine how teachers designed engaging lessons that included interactive activities, opportunities for mathematics discussions, and the types of mathematics tasks.

The third step involved observations of elementary teachers during virtual mathematics instruction using an observational assessment, $MCOP^2$. Raw scores of the $MCOP^2$ ranged from 0–54 using the entire tool and 0–27 if the instrument was used to assess subscales individually. For this study, the teacher facilitation subscore was used. “This instrument was developed to compare groups or measure growth. There is no benchmarks on either factor” (J. Gleason, personal communication, October 31, 2019). Therefore, the results of the $MCOP^2$ were used to compare similarities and differences in the ways in-service elementary teachers designed and implemented mathematics lessons and virtual mathematics instruction.

The fourth step was post-observation interviews. These interviews were conducted to clarify any information documented during teacher interviews and classroom observations. Also, this time allowed teachers to share information about their virtual mathematics instructional practices freely. The last step of data collection was a discussion on the fraction simulation task. This task was designed to build conceptual understanding and was chosen because fractions are a mathematics concept that some elementary teachers struggle to teach and students struggle to learn (Fazio & Siegler, 2011). Also, a fraction task was chosen because both teachers indicated on the MTMSE survey that fractions were a mathematics concept they felt confident teaching to students. Presenting the fraction task would allow the researcher to explore how the teachers would present their students' this task without following a prescribed lesson plan.

At the beginning of each interview, observation, and post-observation interview, teachers were informed that they had a say in how their experiences would be interpreted and used in the results. Confidentiality was maintained by ensuring the teachers' names did not appear in any of the transcriptions or results; all teachers were given pseudonyms. All audio and video recordings, transcriptions, and artifacts from each teacher were stored on a password-protected laptop that only the researcher could access.

Data Analysis

Survey data was analyzed manually since there were only two teachers. The results of these surveys were used to determine teachers' MA and MTSE levels. Statistically, low and high MA and MTSE were selected based on teachers' scores in the lower 25% and the upper 25% of the distribution (Maloney, Risko, Ansari, & Fugelsang, 2009; Haciomeroglu, 2013). Hence, teachers' MA and MTSE scores were determined using these guidelines. Some teachers who experience high MA levels make sure to overly prepare mathematics lessons to feel comfortable teaching (Brown et al., 2011). Teachers with high MA and low MTSE may experience challenges with presenting mathematics concepts to students or lack confidence in helping students understand mathematics. Such teachers' MTSE increases when explaining mathematics concepts to students or creating mathematics materials, and using concrete mathematics examples for teaching (Brown et al., 2011). Teachers who have high MA and low MTSE may struggle with teaching mathematics concepts in general and demonstrate more procedural teaching techniques. Teachers who experience high MA and low MTSE have minimal beliefs about their abilities and skills to be influential mathematics teachers (Swars et al., 2006). MTSE influences teacher's selection of instructional methods and the classroom environment, which ultimately affects student mathematics learning and self-efficacy (Zuya et al., 2016).

Lesson Plan Rubric

A lesson plan rubric[5] was designed inspired by mathematics education literature on lesson planning for mathematics instruction from Superfine (2008), Roche, Clarke, Clarke, & Sullivan (2015), and the observational instrument constructed by Gleason et al. (2015) to analyze teachers' lesson plans. This lesson plan rubric investigated six mathematics instruction components: student engagement, designed mathematical tasks, mathematical questioning, class discourse/student grouping, time allocated for mathematics instruction, and delivery of virtual learning; virtual learning was defined as learning that took place online synchronously or asynchronously for all or some students in a class. These components were highlighted in the mathematics literature as being important aspects of teachers' lesson planning. The following aspects were evaluated:

1) procedural tasks that entailed basic skills and exercises
2) conceptually oriented tasks that promoted problem-solving: thinking, reasoning, and justifying
3) the use of supplemental material used to design mathematics tasks
4) adherence to problems from a mandated textbook
5) purposefully designed questions that assessed and advanced students' reasoning and sense-making about mathematical ideas and relationships

Noting the types of questions, low or high level, was necessary because purposeful questions help teachers understand what students know, so adaptations to lessons can meet various levels of understanding. This practice helps students make necessary mathematics connections and supports students in posing their own questions (NCTM Principles to Actions, 2014).

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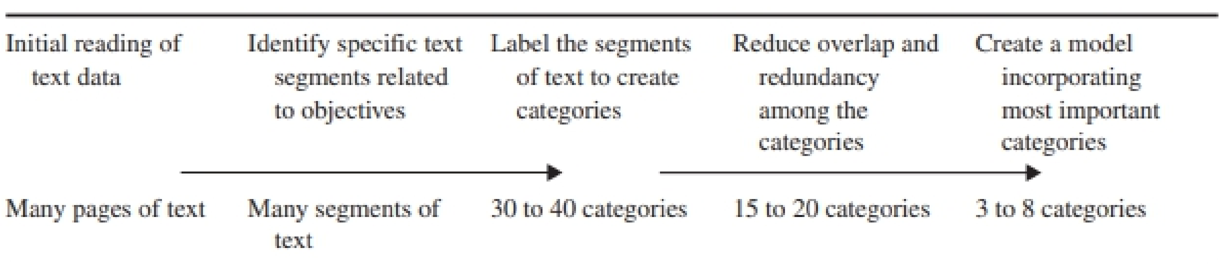
[5] See appendix D for lesson plan rubric

To analyze the data from interviews, teacher classroom observations, post-observation interviews, and the fraction simulation task, an inductive analysis approach was used as prescribed by Thomas (2006). Using the analytical procedures suggested by Thomas, all qualitative methods were analyzed first individually and then collectively. The inductive analysis process consisted of five stages:

1) Preparing and formatting the raw data
2) Closely reading raw data in detail to become familiar and gain an understanding of themes and events
3) Create categories from actual phrases or meanings from the text
4) Overlapping coding and uncoding the raw data based on categories
5) Continuous revisions and refinements of categories. Chose text for quotations to articulate themes or categories.



This diagram shows the coding process in inductive analysis (Thomas, 2006, p. 242). Data from data collection sources were read through individually using a self-efficacy lens to look for keywords or phrases related to teachers' experiences with MA, MTSE, and their virtual mathematics instructional practices. Based on Bandura’s personal self-efficacy theory, teachers who continuously try to improve mathematically experience more success, and those who do not impede their success. Visualizing the four efficacy expectations of *personal self-efficacy,* I focused on the key points described in table 3.3. The information summarized in table 3.3 helped

Table 3.3

Influence of Self-Efficacy on Data Collection Instruments

	Interviews	Observations	Post-Observation Interviews	Fraction Simulation Task
Mastery Experiences	A better understanding & positive views of math. Learned new methods for solving problems. Enthusiasm when teaching. Struggles with math as a student. Negative views about math and math abilities.	Planned tasks that relate to a real-world context. Use of precise math language among teacher & students. Use/non use of manipulatives. High levels of mathematical thinking. Tasks primary uses one procedure for solving.	Revisions made/unmade to lesson plans. Errors made/not made in teaching. Adaptations made/not made to teaching techniques	Previous experiences learning fractions boost or hinder confidence to teach fractions
Vicarious Experiences	Chose to teach based on experiences learning math. The teacher learned effective/ineffective teaching methods from cooperating teacher/peers. Teaching methods similar to the way teacher learned math.	Teacher's questioning encourages/discourages student thinking and conceptual understanding. Teacher creates an atmosphere conducive to learning for all students.	Teacher communicates thoughts about the success/non-success of implemented teaching techniques.	Recall of college methods course learning to teach fractions. Observed someone teaching fractions
Social Persuasion	Feedback from students when they do not understand. Experiences with professional development. Feedback from peers and administrators regarding math instruction.	Students made critical assessments of math strategies used by the teacher	Observed frustration from students during instruction.	Performance feedback from previous lessons taught. Student feedback or struggles learning fractions
Physiological & Emotional Arousal	A shift in thinking about math from negative to positive (or mainly negative). Abstract thinker Negative feelings /experiences with math as a student. Uncomfortable teaching math to students. Anxiety, feelings of stress, and fear when teaching.	Minimal use of mathematical strategies/procedures for problem-solving. Lack of guidance and connections made to a real-world context. Rhetorical and low-level questioning. Minimal to no sharing of student ideas. Lack of conceptual understanding.	Frustration reported from the teacher regarding teaching techniques. Reported challenges during the lesson.	Previous experiences learning fractions (good or bad) Lack of understanding how to teach fractions

the researcher understand some key aspects that might surface from in-service elementary teachers related to MA and MTSE with their virtual mathematics instructional practices.

Next, the process of creating categories or themes from reading the raw data took place using actual phrases and meanings from specific data about MA and MTSE and the teachers' virtual mathematics instructional practices. Since the desired number of interviewees was small, I coded the data to create categories manually. The reduction of overlapping of coding for categories and themes took place to ensure no redundancy among categories and make certain irrelevant information was not evaluated (Thomas, 2006). The last stage of the coding process was to confirm created categories and themes, exemplify the most critical points of view and insights into teachers' experiences with MA and MTSE, coupled with their virtual mathematics instructional practices. Any necessary quotes that conveyed the central essence of teachers' instructional practices influenced by MA and MTSE were selected. The overall intent was to create three to eight categories I felt captured the critical aspects of the themes identified from the raw data (Thomas, 2006). Further, categories that were most important to the phenomenon of MA and MTSE in in-service elementary teachers related to virtual mathematics instructional practices were created.

All data were evaluated for trustworthiness and credibility, as described by Thomas (2006) and validity, as Noble and Heale (2019) represented. Trustworthiness was measured by asking teachers to review interview transcripts for accuracy. Credibility was ensured through member checking, where teachers were asked to verify statements and conclusions made regarding their MA, MTSE, and virtual mathematics instructional practices summarized after individual interviews. The validity of research findings was secured by methodological triangulation utilizing a combination of data collection sources.

Interviews

Highlighting in-service elementary teachers' experiences learning and teaching mathematics was best done by qualitative methods exploring teachers' narratives. Teachers were interviewed better to understand the MA and MTSE surveys' results using a semi-structured interview protocol[6]. The interview protocol sought to obtain additional insight into their experiences having MA and MTSE and their perceptions about their skills and abilities teaching mathematics virtually.

An interview consent form was emailed to all teachers who responded to the initial invitation to participate in this study. The consent form outlined the study's purpose, benefits, and risks of participation, assurance of confidentiality, and contact information should any questions to participate arose. Once the consent forms were returned, interviews were scheduled and took place virtually. Teachers were asked to submit three lesson plans after interviews were scheduled, one for each observation.

The first step of the interview process was to help teachers become comfortable with the interview and sharing their feelings about mathematics. Teachers were asked to share a positive experience with mathematics. The second step of interviews was open-ended questions based on the responses from the MA and MTSE surveys. Sample questions such as Do you believe you have mathematics anxiety? Why or why? And how skilled and confident are you when teaching mathematics? The interviews took approximately forty-five minutes. Interviews were audio and video recorded to confirm the validity of responses and transcribed to compile possible themes.

Teacher Classroom Observations

[6] See appendix F for interview protocol

Teacher observations were conducted to validate information shared in interviews and observe teachers' approach to virtual mathematics instruction. Observations of actual teaching practices unveil how different things teachers know and believe come together in making decisions and pedagogical moves (Kennedy, Ball, & McDiarmid, 1993). Categories of interest were lesson design and implementation, classroom culture and discourse, and student engagement. Teacher observations lasted approximately 60 minutes. Participants identified a lesson they preferred the researcher to observe and the day that was best for their virtual instructional schedule. A total of three observations took place within one week for each teacher so the researcher could capture the essence of mathematical concepts and interactions between the teacher and students within a lesson. According to Kennedy et al. (1993), "observations contribute importantly to the analysis of the different things that teachers know and believe—about subject matter, students, learning, and context—and how those come together in their teaching" (p. 99). Conducting teacher classroom observations gave insight into how urban in-service elementary teachers with MA and MTSE managed their virtual mathematics instructional practices and socially interacted with their students. This opportunity helped to ensure interview responses were not promoted to be socially appropriate.

Post Observation Interviews

Post-observation interviews were the next step in the data collection process, which actual observations could shape. Post-observation[7] interviews were conducted to reflect interesting aspects of instruction that were observed and clarified any actions observed. These interviews helped the researcher explore the influence and rationale for teachers' practices while gaining a view of what they knew and could do during virtual mathematics instruction. Post-observation interviews were held after each teacher had been observed three times. After the

[7] See Appendix G for Post-Observation Protocol

third observation, these interviews took place immediately and were audio and video recorded to confirm the validity of responses and transcribed to compile possible themes.

During data analysis, the researcher had a diversity of perspectives about elementary teachers' virtual mathematics instructional practices (Creswell & Creswell, 2018) to not focus solely on poor mathematics learning attributes to lower confidence in teaching mathematics. However, if such information surfaced, the researcher did not suppress, falsify, or invent information to meet the researcher's desires or audience's needs (Creswell & Creswell, 2018).

Reflexivity

As a mathematics educator of high school and college students I entered this research with a mathematics education background. Based on my experiences teaching, I have witnessed how students struggled with basic mathematics operations with and without calculators. Students have expressed their dislike of mathematics and failures to learn from previous mathematics teachers. These encounters have formed biases that elementary teachers and their mathematics instruction could play an integral role in the misunderstanding students had about basic mathematics. If a teacher experienced MA when they were a student or even as an adult, that MA could appear in their instruction. Hence, they might not be able to teach mathematics to students effectively. Some teachers with MA could avoid teaching higher-level mathematics resulting in teaching only lower grades. Since elementary teachers are educational generalists (teachers of all academic subjects), they are not exposed to the amount of mathematics that mathematics specialists (teachers of mathematics subjects only) must learn.

Besides being a mathematics educator, I am a Black woman in mathematics, a predominately male-dominated field that has taught a diverse population of students in urban settings. I have witnessed the constant struggle students of color have had learning mathematics, not being exposed to multiple teaching and problem-solving strategies, and repeating mathematics courses at both the high school and college levels. Having a mathematics education background influenced the types of questions I asked elementary teachers around mathematics instruction and how they help students gain a depth of understanding of mathematics. I compared the answers elementary teachers provided to my instructional methods and the effective strategies I have used that advanced students' mathematical achievement and performance. With these experiences and thoughts, I kept in mind my positionality as this research was conducted.

Chapter 4
Findings

This research study used a comparative case study approach to explore the nature of Mathematics Anxiety (MA) and Mathematics Teaching Self-Efficacy (MTSE) in two in-service elementary teachers. In addition, I investigated in-service elementary teachers' virtual mathematics instructional practices related to lesson planning and implementation. The research questions addressed were: 1) How are MA and MTSE characterized in in-service elementary teachers?; and 2) How do virtual mathematics instructional practices vary in in-service elementary teachers with different profiles of MA and MTSE? These questions were designed to understand teachers' experiences with MA, how confident they were teaching mathematics to students, and how they approached mathematics instruction in a virtual setting. This chapter presented findings from a comparative analysis across two teachers from surveys, lesson plan reviews, interviews, class observations, and a fraction simulation task. Table 4.1 summaries the findings by themes with data collection sources that support each themes.

Mathematics Anxiety and Mathematics Teaching Self-Efficacy

Bandura's self-efficacy theory was utilized as a lens to analyze the results from all data sources and answer the first research question. Of the four self-efficacy expectations discussed in chapter two, physiological and emotional arousal, mastery experiences, and vicarious experiences were the primary sources that explicitly characterized the nature of MA and MTSE of the teachers in this study. Figure 3 summarized the relationship of MA and MTSE using the self-efficacy theory to arrive at the overarching themes that emerged. Across the two cases, I identified three themes from surveys, interviews, and classroom observations:

1) shifting mathematics perceptions

Table 4.1

Themes and Data Collection Sources

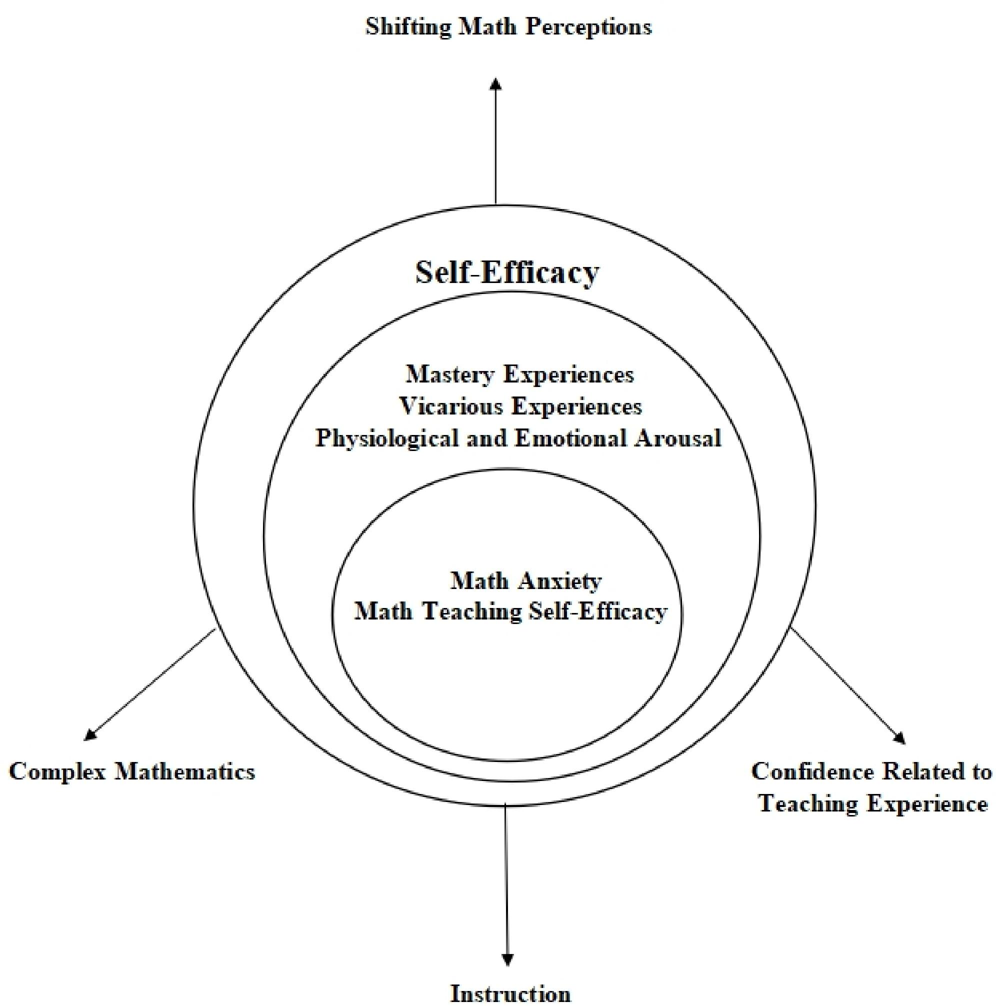
Themes and Sub Themes	Data Sources
Mathematics Anxiety and Mathematics Teaching Self-Efficacy	
Shifting Mathematics Perceptions	✧ AMAS ✧ Interviews
Anxiety-Related To Complex Mathematics Concepts And Instruction	✧ AMAS ✧ MTMSE ✧ Interviews ✧ Teacher Classroom Observations ✧ Post-Observation Interviews
Teacher's Confidence Related To Teaching Experience	✧ MTMSE ✧ Interviews ✧ Post-Observation Interviews ✧ Fraction Simulation Task
Procedural Centered Direct Instruction	
An Overemphasis On Procedural Strategies And Instruction	✧ MTMSE ✧ Interviews ✧ Lesson Plans ✧ Teacher Classroom Observations ✧ Post-Observation Interviews
Impact Of The Virtual Context On Instructional Practices ✧ Virtual Learning Platforms Necessary To Deliver Instruction ✧ Alteration To Instructional Delivery Method ✧ Obstacles With Mathematics Discourse	✧ MTMSE ✧ Lesson Plans ✧ Interviews ✧ Teacher Classroom Observations ✧ Post-Observation Interviews
Obstacles With Mathematics Discourse	✧ MTMSE ✧ Lesson Plans ✧ Interviews ✧ Teacher Classroom Observations ✧ Post-Observation Interviews
Virtual Mathematics Teaching Challenges	
Student Behaviors	✧ Interviews ✧ Teacher Classroom Observations ✧ Post-Observation Interviews
Informal Assessment	✧ Teacher Classroom Observations ✧ Post-Observation Interviews

2) anxiety-related to complex mathematics concepts and instruction

3) teacher's confidence related to teaching experience.

Figure 3

Relationship of MA and MTSE Themes



Shifting Mathematics Perceptions

The two teachers in this case study revealed mixed perceptions about mathematics as a subject, and actual events influenced their perceptions in a negative direction. During interviews, the teachers were asked to speak about one of their most challenging and best experiences with mathematics as a student. Both teachers talked about past experiences with teachers learning mathematics.

Lisa recalled being discouraged from learning mathematics in middle school. She explained,

> it was seventh grade; I had a math teacher who was not too great. Math was a subject I felt probably pretty neutral about when I was a middle schooler, and that experience with this particular teacher really turned me off to math. I didn't complete my assignments the way I should, and I remember getting some pretty bad math grades in seventh grade. It was really due to the teacher and the kind of conflicts I had with her as a middle school student.

Lisa's experience with her 7th-grade teacher influenced her feelings about mathematics in ways that affected her performance. There was a shift in thinking about mathematics, which resulted in incomplete assignments and unfavorable grades. As Lisa continued her educational journey in college, her feelings about mathematics shifted again, but this time in a more positive manner. She had a supportive education methods professor who made learning how to teach mathematics an excellent experience. Lisa stated, "math is different these days than how I learned it as a kid, so I really latched onto the methods that he showed us and how to best teach math to younger children." Lisa's experience learning how to teach mathematics from her methods professor is a classic example of a vicarious experience. Her observations of him teaching mathematics increased her confidence to utilize various ways to teach mathematics to students.

Ultimately, Lisa's encounter with her 7th-grade mathematics teacher changed her perception of mathematics which negatively affected her mathematics performance. Yet, experiences with her college professor positively changed her feelings about mathematics and supported her ability to teach mathematics to her students.

Marie faced many challenges learning mathematics. Her mathematics experiences stimulated negative beliefs about her ability to learn mathematics so much that she could not recall one positive experience as a student learning mathematics. When asked to share one of her best mathematics experiences as a student, Marie said,

> I'm not going to lie to you. I actually was a terrible math student. I didn't like math; I was extremely low. I wasn't very successful until about college with math. [That] wasn't my thing, wasn't my subject.

According to the Abbreviated Math Anxiety Rating Scale (AMAS), Marie was identified as having moderate MA; her score was 28. She shared a time when she struggled to remember multiplication and division fluency facts while playing a game entitled All Around the World. One of Marie's teachers used this game to help students practice fluency facts. Marie expressed,

> I hated it because you're put on the spot, and if you lose, everyone boos you, and I just felt so hurt that I just couldn't comprehend it [fluency facts]. I couldn't understand; I couldn't like retain those facts as fast as the other kids.

Through mastery experiences, one can understand Marie's unsuccessful attempts to learn multiplication and division fluency facts. Her unsuccessful attempts to understand multiplication and division fluency facts caused her to develop the perception that she could not learn mathematics. Physiological and emotional arousal helps visualize Marie's emotional state and disappointment while playing the game to recall those fluency facts during class. Marie formed negative thoughts about her ability to do well in mathematics which formulated unpleasant emotions. Further, the experience playing All Around the World could be related to Marie distinguishing herself as a terrible mathematics student and not favoring mathematics.

Unpleasant experiences learning mathematics can trigger many emotions that caused Lisa and Marie to have negative perceptions about mathematics. These situations could also explain how Lisa and Marie developed feelings of MA. Early awareness of MA can promote doubt about an individual's ability to be a successful mathematics learner. Struggling to understand mathematics from childhood and undesirable experiences while learning mathematics affected Marie more and made her believe she would never overcome MA even though she taught mathematics.

Mathematics Anxiety Related to Complex Mathematics

Although case study participants expressed anxiety with mathematics in general while reflecting on past learning experiences, they also disclosed feelings about more complex mathematics. Survey results from the AMAS revealed that both teachers experienced some anxiety when presented with challenging mathematics problems.

Lisa was identified as having low MA; she scored a 14 on the AMAS. She did not report having MA with elementary mathematics concepts that she taught. The Mathematics Teaching and Mathematics Self-Efficacy (MTMSE) survey revealed that Lisa was confident in understanding mathematics concepts well enough to teach elementary mathematics effectively. However, interview responses disclosed that she experienced MA when she prepared for the Praxis II exam, a test that measures the academic skills and subject-specific content knowledge needed for teaching. Preparing for this exam caused feelings of anxiety because Lisa reviewed mathematics content that she did not recall learning. Further, she had some anxiety with middle and high school mathematics concepts. Lisa stated,

> if there was a concept that was confusing to me that I didn't feel solid with, I'm sure that I would get flustered and stumble over my words and probably confuse the students. I think that the students would be confused because I would be confused. I personally would like, get red in the face and be very unsure of what I was saying.

To gain more insight into Lisa's thoughts about what MA would be like teaching a higher level of mathematics, I probed during the post-observation interview to see if specific mathematics concepts would raise increased feelings of anxiety. Lisa could not pinpoint any particular mathematics concepts that led to feeling more anxious. Yet, an experience as a substitute teacher in 7th and 8th-grade classes seeing mathematics concepts that she was unfamiliar with led her to believe that she could not assist the students if they needed help or teach these grade levels. Bandura's efficacy expectation, physiological and emotional arousal, can be understood by Lisa's feelings regarding more complex mathematics reflected in decreased confidence to teach any grade level higher than elementary. Her emotions and lack of memory of higher-level mathematics concepts decreased her confidence in teaching middle school mathematics, although she was certified to teach those grades.

On the other hand, Marie reported explicit feelings of anxiety related to mathematics. Her reservations about mathematics went beyond teaching mathematics concepts to students. Marie was not confident about real-world mathematics situations. Marie asserted,

> I don’t feel confident in other aspects of math, like adding tips or trying to figure out sale prices. I wonder never be one to go out of my way to explain something mathematically unless it was 5th-grade elementary school-related because I just never understood math until I taught math.

Marie lacked confidence and experienced MA when she was a novice teacher. As she gained more experience, she felt more confident about teaching elementary mathematics. Marie struggled to understand mathematics concepts and their relationships; hence there was a need to have those concepts repetitiously explained to her. Marie's MA was evident through this statement, "it just took me forever to understand, because I just felt so anxious about, you know, I'm an adult, and I should understand a fifth-grade topic, and I just don't understand." Additionally, it was evident during the interview that Marie experienced MA when she encountered unfamiliar mathematics concepts; she felt intimidated. One of Marie's concerns was comprehending the mathematics concepts and retaining the information to teach that content. This anxiety experience affected Marie's comfort in responding to students' questions during instruction.

Mathematics Anxiety Related to Instruction

One case study participant noted her capability in teaching mathematics; however, specific feelings of MA surfaced during mathematics instruction. While anxiety reactions might be hard to observe, an individual's inner emotions can signal fear-induced thoughts of their effectiveness to perform. According to results from the MTMSE survey, Marie believed she would be able to answer students' questions, and when teaching mathematics, she would usually welcome students' questions. Nonetheless, Marie's interview responses contradicted the MTMSE survey results because Marie's MA carried over into her mathematics instruction. Marie feared she would not be able to answer students' questions, and she vividly explained,

> I just shut down completely, you know, I [had] to respond with, I need to get back to you. It is like a, oh man, moment like a fifth-grader got me, but that's

how I [felt]. Like they [students] stumped me. And as an almost 30-year-old woman, I had to like get back to a ten-year-old.

Marie believed students asked deep, open-ended questions, and she would not feel confident to provide an answer. Marie's shutting down, not having an immediate response for the students, and feelings of defeat were examples of the emotional state that made her believe she would struggle to respond to students' mathematics questions. She associated her feelings of MA with having to think and give answers quickly. In these instances, she assumed that she would provide incorrect answers and experience physiological reactions depicted as "everything is closing in on me, and everyone's just staring at me and waiting on me." Physiological and emotional arousal informs Marie's inner emotions that signaled a lack of confidence to teach mathematics.

Classroom observations validated Marie's anxiety when teaching mathematics. On occasions, she asked students questions and disagreed before they could complete their thoughts or justify their thinking. There were also instances where Marie provided an inadequate amount of wait time before she gave answers to questions she posed. These occurrences might suggest that Marie experienced MA and reflected on incidents when she could not provide an accurate response to students' questions. When students posed questions that she did not know how to answer, Marie's anxiety may have caused her to minimize students' chances of communicating during instruction.

Teacher's Confidence Related to Teaching Experience

In this case study, the teachers reflected on a boost in confidence in teaching mathematics, resulting from years of teaching 4^{th} and 5^{th}-grade mathematics. Teaching experience is a good indicator of a teacher's assurance to teach academic subjects. Lisa had ten years of mathematics teaching experience, and Marie had four years of mathematics teaching experience. Based on the

MTMSE, Lisa and Marie were classified as having high MTSE. They felt confident in their abilities to teach mathematics to students. Interview results also supported both teachers' confidence to teach mathematics, situated in 4th and 5th-grade mathematics concepts.

Mastery experiences demonstrated these teachers' confidence in teaching elementary mathematics concepts. Through consistent practice solving mathematics problems and familiarizing themselves with the mathematics concepts before introducing them to students boosted their confidence in their ability to teach mathematics effectively. Lisa specifically utilized online resources to help increase her confidence in teaching mathematics. As a novice teacher, Marie did not feel confident in teaching mathematics; however, she taught multiple mathematics classes each day. The repetition of doing so and presenting mathematics concepts using different methods increased her confidence to teach mathematics.

Even though both teachers were highly confident in their ability to teach elementary mathematics concepts, their confidence decreased when presented with the idea of teaching middle school mathematics concepts. Marie stated,

> I just [felt] like if they gave me 6th, 7th, or 8th-grade work and they were like, you need to teach this, I would probably call in. I'm not going to lie; I would not feel well about it. I kind of shut down a lot more.

Lisa's thoughts showed that she would also feel uncomfortable teaching middle school mathematics. She felt becoming familiar with the mathematical concepts in grades 6th-8th would be a priority since many years had passed since she was exposed to teaching these grades. After hearing those responses during the post-observation interview, I probed to understand the difference between learning how to teach 4th-5th grade mathematics versus learning how to teach

6^{th}–8^{th} grade mathematics. These teachers had taken elementary and middle grades mathematics content and methods courses and were both certified as K–8 teachers. Marie's insight was thought-provoking as she explained when she took mathematics methods courses during college, she was learning the mathematical concepts, not how to teach the concepts. Now that she was required to teach specific mathematics concepts that she was not confident about, she could better understand them. Marie asserted,

> I think maybe if I was taught this [fraction arithmetic], I might be different now. I wouldn't feel confident with fractions when I was in college, and now that I'm teaching it and I'm learning different outcomes of them [fractions], it's like all of a sudden something clicked in my brain where I'm like, holy moly, now I understand how fractions work now.

Marie was not confident with understanding fractions, but she understood fractions because she taught mathematics. Her thoughts about teaching mathematical concepts related to her responses from the fraction simulation task. Marie perceived that her students also lacked an understanding of fractions; therefore, she wanted to alter the fraction task to ensure her students would better comprehend fraction arthritic. Marie's actions might suggest that she recalled her prior understanding of fractions and sought to ensure her students did not struggle as she did. Marie stated, "I just don't want any of my kids to go through what I went through, and I want them to love math."

Ultimately, low confidence in teaching unfamiliar mathematical concepts increased MA for the teachers in this study. When these teachers were teaching elementary-level mathematics, they experienced less MA and had high MTSE. Further, these teachers were more comfortable with mathematics content that they have taught for years; therefore, teaching experience boosted their confidence to teach elementary mathematics. If these teachers were asked to teach middle school mathematics, they would experience some MA, and their MTSE would not be as high as when they were teaching 4th or 5th-grade mathematics. Lastly, one teacher experienced an increase in MA when presented with student questions because she believed she was incapable of providing adequate answers.

Summary

Lisa and Marie's past experiences learning mathematics showed that environmental, intellectual, and personal factors played a significant role in their MA and MTSE. They had negative experiences learning mathematics during their K–8 grade education. The teachers they encountered and activities used for mathematics instruction made them feel inadequate learning mathematics, which then developed into a negative mindset about their ability to perform well in mathematics. Lisa and Marie experienced MA with unfamiliar mathematics concepts they must present to students. In this situation, they were self-motivated to seek assistance and resources to reduce their anxiety and build their confidence to teach unfamiliar mathematics concepts. With years of teaching experience, Lisa and Marie had positive views about mathematics and enjoyed teaching mathematics to their students.

Lisa's experience with MA and MTSE was an excellent example of how one can overcome past experiences learning mathematics and grow to enjoy mathematics in ways that can positively impact their future life and career. According to Lisa, MA and low confidence in mathematics resulted from a mindset that one believed they did not know how to do the mathematics, could not do the mathematics, or was not good at mathematics. Lisa's experience with MA and MTSE can be summed up by her words,

> …experience improves effectiveness, the more effective I am, the more confident I am, and it is sort of like a cyclical thing. The more I teach it [math concepts], the better I understand it, and the better [I] understand how to deliver it, that makes me more confident.

Bandura's self-efficacy theory suggested that repeated success could decrease MA and stimulate growth in a teacher's MTSE.

Marie had occasional MA episodes that made her question her ability to teach mathematics. Still, she did not allow herself to become defeated. She persevered by revisiting mathematics concepts and students' questions at later times. Marie's experience with MA and MTSE is evident through two of Bandura's efficacy expectations: mastery experiences and physiological and emotional arousal. As a student, Marie faced plenty of unpleasant experiences learning mathematics; nonetheless, she developed a better understanding of mathematics and held more positive views. Since Marie experienced so much misfortune learning mathematics as a student, she endeavored to make mathematics enjoyable for her students, so they did not have similar experiences. Taking the time necessary to prepare herself and think about potential student mathematics questions increased her confidence to teach mathematics.

Procedural Centered Direct Instruction

The second research question for this study was: How do virtual mathematics instructional practices vary in in-service elementary teachers with different profiles of MA and MTSE? To answer this question, I employed the MCOP^2 observation protocol for three classroom observations for each teacher to investigate their virtual mathematics instructional practices. More specifically, if teachers used direct instruction or student-oriented instruction utilizing lessons that were procedurally or conceptually oriented. Also, interviews, post-observation interviews, and a fraction simulation task were analyzed inductively using Thomas's (2006) methods. Findings indicated that in-service elementary teachers heavily relied on direct instructional practices with a focus on procedural strategies. To explain this finding several themes emerged and the most compelling themes that described the teachers' virtual mathematics instruction were:

1) an overemphasis on procedural strategies and instruction
2) impact of the virtual context on instructional practices
3) obstacles with mathematics discourse.

Overemphasis On Procedural Strategies and Instruction

Interviews revealed that the teachers in this study were conceptually minded when teaching mathematics, while their virtual instructional practices revealed procedurally oriented mentalities. The second part of the MTMSE survey concentrated on teachers' orientation to instruction-procedural or conceptual. An example of a procedural question was; the teacher's primary role is to carefully demonstrate new mathematics problems. Models of conceptual questions were;

1) I frequently ask my students to explain why something works
2) with topics I am more confident teaching, I am more likely to explore alternative teaching strategies.

Lisa and Marie reported to be conceptually oriented with mathematics instruction rather than procedurally oriented, with scores falling in the higher range: Lisa's subscore was 45/60 (75%), and Marie's subscore was 49/60 (82%). Both teachers strongly agreed that they frequently asked their students to explain why something works, a conceptually directed statement. Interview discussions verified that both teachers were conceptually oriented when teaching mathematics. During interviews, teachers discussed mathematics concepts related to real-world context and explored mathematics concepts using manipulatives. These practices helped students better understand the mathematics content and strategies for problem-solving. The teachers also elaborated on class discussions that involved the why behind using specific methods and why certain answers made sense for mathematics problems. Teacher lesson plans and classroom observations revealed inconsistencies with what the teachers reported on the MTMSE survey and interviews.

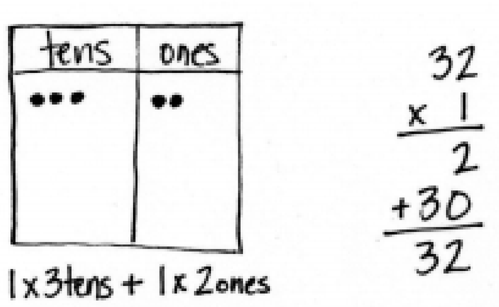
Lisa's lesson plans were divided into three sections: fluency practice, concept development, and formative assessments. Concept development was comprised of two problems set up as I do's-we do's-you do's. Word problems were included in her plans; however, one was crossed out to indicate that she would not cover it. Lisa's mathematics lesson focused on using place value charts with place value disks and the standard algorithm to solve two and three-digit multiplication problems. Lisa adhered to the appropriate mathematics standards, but no guidance to real-world connections was made. Figure 4 illustrates an example of the types of problems Lisa reviewed with her students.

The focus was placed on procedures to solve mathematics problems without students understanding the why behind procedures. Although students had various entry points into solving these problems, the students were not provided with sufficient time to examine mathematics structure. Lisa controlled instruction explaining how to solve the mathematics problems without allowing students multiple chances to discuss their thinking.

Lisa's actions could be interpreted by her response on the MTMSE survey related to a teacher's primary role during instruction. Lisa felt neutral about the statement a teacher's primary role is to demonstrate new mathematics problems carefully.

Figure 4

Place Value Chart Demonstration



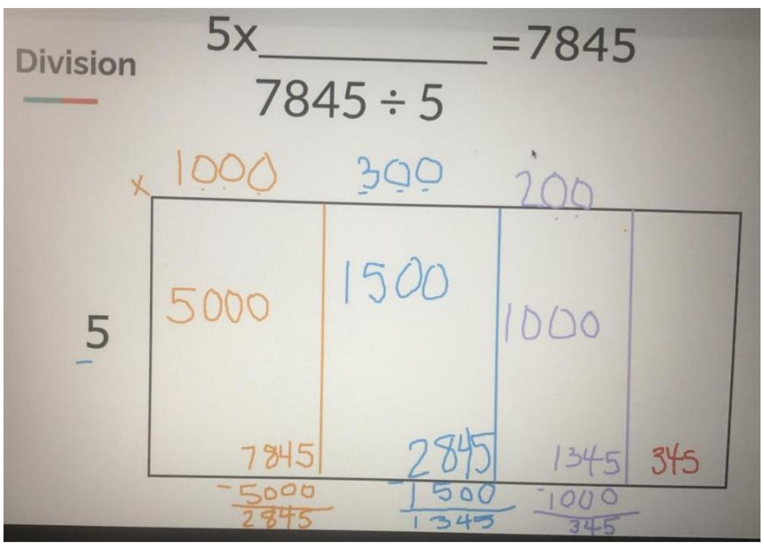
She was observed applying direct instructional practices in all three mathematics lessons. Lisa explained during the post-observation interview that time constraints were a serious problem that resulted in her relying on direct instruction.

Marie's lesson plans had more details that included teacher and student prompts and opportunities for students to discuss their thinking and solutions through think-pair-shares. Her lesson plan included at least two chances for students to work together during think-pair-shares for each lesson. Low-level mathematical questions were built into her lesson plans to aid students' thinking and problem-solving. Marie's lessons focused on using area models and repeated subtraction to solve long division problems. When these methods were introduced, there was no connection to a real-world context.

Nevertheless, Marie encouraged relational understanding by explaining the 'why' behind procedures during all three classroom observations. Some students also explained why or why not a strategy led them to an answer. Though Marie spent time covering why the strategies worked for solving these problems, she missed several opportunities to relate mathematics concepts and student questions to a real-world context. The mathematics problems covered were procedural, and two representations of how to write and solve the problems were discussed. For example, students were given the problem 7845 ÷ 5 and asked to represent it using multiplication, then solve it using an area model. Figure 5 presents the exampled problem solved by Marie and her students.

Figure 5

Division Problem Solved Using an Area Model



Marie experienced frustration while exploring area models with her students. She did not favor this method as it was challenging for students to understand and difficult for her to present. Marie stated during the post-observation interview, “I didn't like the area model too much. I thought that was a little chaotic. I understand the reasoning behind it, but it's just a lot for the kids to understand.” Observing Marie teach this problem, I sensed her frustration when she disagreed with students before completing their responses to her questions. She minimized students' freedom to discuss the problem-solving process with her as students wanted to participate, but she controlled that process. This situation could be related to Marie’s anxiety when responding to student questions. Although she reported on the MTMSE survey, she would typically welcome students' questions; in reality, their questions may have caused an increase in Marie’s MA.

During the post-observation interview, Marie consistently referenced her disapproval of the area model and wished she had given more thought to its execution during lesson planning. Although Marie considered the area model to be too complicated for her students to comprehend because it involved several steps to arrive at a solution and students might get lost in understanding the process, her responses during the interview revealed her lack of confidence with the area model. She was not familiar with teaching division using an area model, and she did not prepare herself during lesson planning. Marie stated,

> I wish I would have kind of reviewed it [area model] a little bit more. In my head, it made sense; executing it did not make sense. As I was executing it, I was like, this is confusing even for me as a 30-year-old, so how do I expect a ten-year-old to understand this.

The MTMSE survey showed that Marie would explore alternative teaching strategies with mathematics topics she was more confident teaching. Nonetheless, when it came to presenting the area model, that was not the case. This circumstance might imply that Marie was confident teaching division but only using less complicated strategies. When she taught division the following day, she did not have any frustration implementing the repeated subtraction strategy.

Generally, Marie’s students were given many opportunities to work independently, explain their solutions, and explore more than one strategy to arrive at an answer. Although two strategies were presented to solve mathematics problems, Marie's comparison of the strategies was generalized in a simplistic fashion-one was easier and faster than the other. The students did not discuss their preferred path to a solution or why a specific approach helped their understanding. Further, students messaged her during class sharing their frustration and misunderstanding using the area model.

Lisa and Marie were conceptually minded about mathematics instruction; however, teaching mathematics virtually, their instructional practices were procedurally oriented. Their lesson plans included procedural and conceptual mathematics tasks. Still, only the procedural mathematics tasks were implemented during virtual mathematics instruction. Lisa assigned one conceptual task to her students as an exit ticket, but no class discussion of students' work, thoughts, or problem-solving strategies took place before class ended or the next class session. Marie presented one conceptual mathematics task (a word problem), but it was solved procedurally. This word problem will be addressed in the next section.

Impact Of The Virtual Context On Instructional Practices

The teachers in this case study considered various modifications that impacted their delivery of virtual mathematics instruction. They considered:

1) virtual learning platforms necessary to deliver instruction

2) alteration to instructional delivery method

3) obstacles with mathematics discourse.

Virtual Learning Platforms. Effective online platforms were needed to deliver mathematics instruction virtually. These online platforms should not compromise or diminish the learning outcomes students might receive during in-person instruction. Lisa and Marie used different online platforms to deliver mathematics instruction and similar platforms to assess student mathematics learning. Table 4.1 summarized the online platforms and programs the teachers used for virtual mathematics instruction.

Table 4.2

Online Platforms

Lisa	Marie
Google Meet	Zoom
Seesaw	Seesaw
Pear Deck	Pear Deck
Zearn	Go Guardian
Google Slides	Google Slides
Google Docs	Reflex and Freckle Math
Khan Academy	
Compass Learning	

Lisa taught in a hybrid model where she had students learning in-person and virtually simultaneously. She used Google Meet for virtual mathematics instruction. Marie taught 100% virtually and used Zoom for mathematics instruction. Both teachers used various platforms to assess student learning and provide students with methods to solve mathematics concepts. When one platform was inefficient, they relied on other platforms. Lisa and Marie were motivated to ensure they researched online platforms that would support their virtual mathematics instruction. The two platforms that were discussed in detail during interviews were Seesaw and Pear Deck.

Seesaw supported virtual mathematics instruction because it was easily accessible for students to complete assignments, for teachers to provide feedback, and communicate with their students. Also, parents were provided access to Seesaw to monitor their child's assignments and communicate with the teachers. Peak Deck was an interactive platform that allowed teachers to informally check for understanding while students completed practice problems during instruction. Pear Deck allowed Lisa and Marie to view students' mathematics work instead of relying on physical whiteboards.

Lisa and Marie utilized various online platforms to deliver mathematics instruction virtually. They were comfortable with Google Meet and Zoom for mathematics instruction and communicating with their students. Platforms such as Seesaw, Pear Deck, Go Guardian, Reflux and Freckle were used to assess student mathematics learning. Some platforms were more effective than others, but both teachers were motivated to try various platforms for different aspects of evaluating student mathematics learning.

Alteration to Instructional Delivery Method. On the MTMSE survey, Lisa and Marie strongly agreed that they would continually find better ways to teach mathematics. However, when they had to deliver mathematics virtually, they solely relied on direct instructional practices.

Lisa used a great deal of modeling to solve the mathematics problems first, and then the class solved the problems together. This method was known as I do-we do-they do, explicitly demonstrated in her lesson plans. Lisa hoped using this form of modeling was effective; she trusted it worked well for fourth graders. Lisa stated, “our curriculum is pretty set, so like we're kind of just expected to follow it mostly. So I mean, sticking with what they're telling me to do.” In recent years Lisa was given autonomy to make changes to mathematics lessons and instructional techniques; nevertheless, she adhered to required mandates set forth by her school.

Lisa’s lesson plans did not demonstrate any chances for students to work in pairs or groups. During teacher class observations, I noticed students did not work in groups; therefore, during post-observation interviews, Lisa was asked if any modifications were made to her lessons or content that did/did not work with the virtual learning transition. She mentioned, usually, students would be given a great deal of time during the lesson to work in groups without a lot of direct instruction. When asked why Lisa did not implement small group instruction, she referenced time constraints and further explained that breakout rooms were available for her to use; yet, she chose not to use them for mathematics lessons, only ELA lessons. Lisa believed that students would be in breakout rooms unsupervised; therefore, it would be challenging for her to manage them. Instead of implementing group work, Lisa used two online platforms-Zearn and Compass Learning, to monitor students’ individualized learning.

Marie taught mathematics concepts by including her students in a step-by-step process of solving and explaining mathematics problems while soliciting their thoughts. Marie stated,

> them [students] speaking and explaining their answers is a little harder in zoom, but I utilize that one [technique] a little bit more because student language is just different than teacher language. They just explain it [math problems] in a way that their peers usually tend to get a little easier than me explaining it for them.

Marie considered whole-class instruction useful because students could discuss their thinking and present their work to help other students better understand the mathematics concepts. She called her students teachers in this regard and allowed them to use their whiteboards to demonstrate and explain their work to the class. Marie favored using whiteboards when presenting mathematics concepts during mathematics instruction. She had a large whiteboard for virtual mathematics instruction because it was more effective than using a computer for certain mathematics concepts.

Marie shared similar views about student groups in that it would be challenging to manage the students while in breakout rooms. Marie believed that small groups were helpful; however, she only implemented them with certain classes. The students in the class I observed lost their privileges to work in groups due to a lack of trust and minimal student participation. Marie expressed that this class of students had not learned how to work in groups virtually. She said these students must understand how to remain on task and work together without logging out of the learning platform or browsing other websites.

Students from both classes were not afforded opportunities to work in groups to discuss their mathematics thinking, reasoning, and problem-solving techniques. Although Lisa and Marie spoke about group work effectiveness and consistently used student groupings during in-person learning, small groups were not implemented for virtual mathematics instruction.

Obstacles with Mathematics Discourse. The teachers in this study provided distinct environments for mathematics discourse to take place during virtual instruction. It is the classroom teacher's responsibility to foster mathematical understanding and create an environment where students can develop their mathematical knowledge. Students need opportunities to discuss their thinking during mathematics lessons, critique others' reasoning, and ask questions.

Lisa struggled with class discussions and encouraging students to respond to questions. Lisa's talk during lessons adhered to a basic recall of facts and correct usage of mathematics language. The relationships between using place value charts and the standard multiplication algorithm were made as discussed by her. Lisa's decision to dominate class discussions could be implied by her desire to ensure her students had a depth of understanding of basic mathematics facts. According to the MTMSE survey, Lisa agreed that she liked her students to master basic mathematics operations before tackling complex mathematics problems. While noting this aspect, her students' thoughts, evaluations, and discussions around multiplication concepts were rarely evident during instruction. Overall, not many students verbally contributed during the lessons. Interview responses also supported why Lisa might have struggled with mathematics discourse related to her students' prior knowledge of multiplication facts. Lisa expected her students to understand better multiplication facts, rules, and problem-solving strategies. These were the necessary mathematics skills students needed to learn the concepts she covered successfully. Lisa said,

> it is surprising to me how little they understand about multiplying two-digit and three-digit numbers by one digit. It seems almost like they have no background knowledge, which is a little bit unusual. Usually, they come with more understanding of the different strategies that we use, especially that standard algorithm strategy.

When her students knew all of these skills, it allowed her to breeze through lessons instead of spending a lot of time discussing those necessary skills.

During post-observation interviews, I asked Lisa to elaborate on the small number of students who shared and discussed their thoughts during the lessons. Lisa explained that she generally called on the students who were in person because she believed they followed along with her. The same few virtual students were called upon because they volunteered to participate. Yet, she focused more on the in-person students. I probed further to understand why these opportunities were reduced or did not exist during virtual learning. Lisa stated

> time constraints are the challenging part. Without having them [students] in front of me to like force them to engage, it will be the same three or four students who are going to be participating…calling on students has definitely been lost in this virtual world.

When virtual students had questions, they were posed through Google Hangouts or the Google Meet chat function. Overall, Lisa's classroom climate supported students who understood the mathematics concepts or participated during the lesson. Some students shared or commented during the class while others sat quietly.

Mathematics discourse in Marie's class was intriguing. Sometimes students actively engaged in class discussions, and other times she minimized those opportunities. One instance when this situation took place, a student offered an incorrect strategy, and Marie's reply was, "no, I'm not confident this is what we should try." As stated previously, Marie had concerns with providing answers to students' questions. Hence her response to the student's discussion of an incorrect strategy might suggest that she was not confident about discussing the student's wrong approach. Her actions could be understood through Bandura's physiological and emotional arousal, in which Marie experienced an increase in MA when speaking mathematically with her students. Besides that situation, students generally explained and discussed their solutions and strategies while commenting on other students' work. During these times, Marie sought a thumbs up or down to agree or disagree with classmates. Students explained why they agreed or disagreed with their classmates' work.

Though these occurrences took place, there were several opportunities when Marie could have encouraged student thoughts and problem-solving strategies before offering her views. For example, when she presented the word problem in Figure 6, it would have been beneficial to explore students' approach to solving without her direction and discuss the problem and solution in its context.

Figure 6

Marie's Application Problem

Word Problem
the principal Mr. Smith bought a bunch of markers for the fourth and fifth grade classes. He bought 1,491 markers and there are 7 fourth and fifth grade classes. And we need to help him divide them up equally – he's not sure how many markers to give each class.

As Marie presented this word problem to students, she gave them a strategy to use, and they discussed each step needed to achieve an answer. After a solution was reached, students did not discuss what that solution meant in the context of the problem. While solving this mathematics problem, it would have been great to have students discuss strategies for determining the number of markers each class should receive and discuss the answer in the problem's context.

Overall, the climate in Marie's class supported mathematics learning and understanding for all students. The same students were regularly called upon; though she attempted to call on various students, some did not respond. Many students shared their thoughts, ideas and communicated their struggles and explanations of mathematics problems during mathematics instruction.

Lisa and Marie experienced some challenges promoting mathematics discourse during virtual mathematics instruction. Lisa appeared to have more issues than Marie in that she only focused on students that learned in-person and a couple of students learning virtually. Lisa dominated mathematics instruction explaining how to solve all problems, rarely allowing her students to think, justify, or explain their thoughts and strategies. Conversely, Marie's virtual mathematics instruction included student-led discussions of their justifications for using strategies and student critiques of their classmate's work. Marie persistently encouraged student mathematics discourse, although there were instances where her responses could discourage student communication. She used humor and incentives to increase class discourse and participation.

Virtual Mathematics Teaching Challenges

Conforming to a new way of teaching and interacting with students can be an adjustment for educators. One adjustment for educators during the COVID-19 pandemic was adapting to virtual instruction. Teaching mathematics specifically in a virtual setting could present teachers with another layer of challenges. Learning how to navigate online platforms, modify curriculum and lesson plans, and adjust lesson timing were examples of some challenges teachers in this study experienced. However, the most discouraging challenges were summarized into two categories; student behaviors and informal assessment.

Lisa and Marie expressed disappointment with two types of student behaviors: students having their cameras off during instruction and student disruptions. These teachers believed that they could not require students to have their cameras turned on during class. Some students had their cameras off during the entire class or consistently switched them on and off. When students did not have their cameras on, the teachers were unsure if they were engaged and understanding the mathematics concepts. This situation made it challenging for Lisa and Marie to monitor students' mathematics learning. Observing teachers' virtual mathematics instruction, less than 50% of students participated during the three lessons. Although some students were logged into class, they were not actively participating. During these times, the teachers checked in with those students to know if they were following along. These check ins were more surface level to know if students were following along and adhering to procedures. Some students remained silent, and some turned on their cameras to show their faces, then instantly turned their cameras off.

Teaching mathematics virtually also made it difficult for Lisa and Marie to assess students' mathematics understanding informally. It was hard for them to observe students' work, catch their mistakes and misconceptions as they solved problems during class. This situation was challenging for Lisa because she taught using a hybrid model. She had to monitor students in person and virtually simultaneously. Marie wished that students could have placed their cameras in a position that allowed her to see their work as they solved mathematics problems. Since both teachers elaborated on Pear Deck's effectiveness, it would have been an excellent opportunity to utilize it to view students' work while solving mathematics problems during mathematics lessons. Lisa and Marie both indicated that Pear Deck enabled them to check students' understanding and view their work while on screen.

When mathematics concepts were presented, Lisa and Marie were not confident their students understood because some students did not respond to teacher questions, and several students did not complete assignments. During some of these instances, students would message each other or their teachers. These actions disrupted mathematics instruction. Listening to these circumstances, I wondered if students were learning and understanding mathematics the same or differently from mathematics instruction in person. Both teachers reported that students understood mathematics concepts differently due to low retention of mathematics concepts and not having an in-depth understanding of mathematics content covered. Students in Marie's class were provided anchor charts and other resources to help prepare them for mathematics tests; however, her students still struggled to retain the information. Lisa assumed her in-person students gained a more in-depth understanding of mathematics concepts than her virtual students. However, both sets of students paid attention during class, practiced the examples during instruction, and completed assignments. Lisa stated that this year, many students did not understand the mathematics concepts how students did when they learned in person.

There could be a variety of challenges that teachers face when teaching mathematics virtually. Some issues might be more manageable to work through, while others present more difficulties. Because of these challenges, Lisa and Marie expressed their desire to return to face-to-face mathematics instruction as soon as circumstances improved with the COVID-19 pandemic.

Conclusion

This study's findings revealed many interesting aspects about MA, MTSE, and virtual mathematics instruction at the elementary level. First in-service elementary teachers' unpleasant experiences as students with their teachers caused them to develop negative mathematics perceptions. These negative mathematics perceptions developed into MA feelings, which promoted doubt about their ability to learn mathematics successfully. Teachers experienced MA related to teaching complex mathematics and instruction when faced with in-depth student mathematics questions. Teachers did not feel anxious about 4^{th} and 5^{th}-grade mathematics concepts and were confident teaching these grades. However, these teachers' MA would increase, and their MTSE would decrease if they taught or assisted students with middle school mathematics concepts.

Mathematics lesson plans were prescribed and the teachers adhered to these lessons with no adaptations and several modifications to virtual mathematics instruction. Procedural and conceptual mathematics tasks were included in the lesson plans. Virtual mathematics instruction was teacher-dominated using direct instructional practices, and students were not given opportunities to work in pairs or small groups. Teachers implemented virtual mathematics instruction through various online platforms and implemented supplemental platforms that supported their virtual mathematics instruction. Though teachers were conceptually minded when planning mathematics lessons, mathematics tasks were presented procedurally. A conceptual understanding of word problems and making connections to a real-world context was not evident in neither of the classrooms observed. Nonetheless, relational/conceptual understanding was apparent in one classroom as the teacher discussed why specific strategies were appropriate for solving mathematics problems.

Creating an environment conducive to mathematics discourse was problematic for teachers during virtual mathematics instruction. Occasions for students to make sense of problems and explain their thinking was minimized in one class whereas promoted in the other. Teachers also struggled to maintain student engagement, for less than 50% of students participated in the lessons. Some students had their cameras turned off, refused to respond to teacher questions, and disrupted the learning environment.

Chapter 5
Discussion

The relationship between Mathematics Anxiety (MA), mathematics teaching self-efficacy (MTSE), and mathematics instructional practices have been investigated in pre-service elementary teachers (Ashcraft, 2002; Bates et al.,2013; Brown et al., 2011; Franks, 2017; Gresham, 2009; Hadley and Dorward, 2011; Hembree, 1990; Hughes, 2016; Swars et al., 2006; Wood, 1988; Zuya et al., 2016). Research with in-service elementary teachers was much more limited, and studies have solely reported MA, MTSE, and in-service elementary teachers' mathematics instructional practices. This qualitative comparative case study was designed to explore the relationship between MA, MTSE, and the virtual mathematics instructional practices of in-service elementary teachers using Bandura's self-efficacy theory as an interpretive lens.

This comparative case study included two in-service elementary teachers who taught 4th and 5th-grade in two different schools from a Midwestern urban school district. An explanatory design was chosen to explain similarities and differences of how the teachers described their MA and MTSE and the influence these constructs had on their virtual mathematics instruction. Data were collected for this study using the Abbreviated Mathematics Anxiety Rating Scale (AMAS; Hopko et al., 2003), the Mathematics Teaching and Mathematics Self-Efficacy survey (MTMSE; Kahle, 2008), mathematics lesson plans, semi-structured interviews, teacher classroom observations, post-observation interviews, and a fraction simulation task. In this chapter, I interpret significant findings, discuss the study's limitations, and explore potential implications for research and practice.

Characterization of Mathematics Anxiety and Mathematics Teaching Self-Efficacy

The findings from surveys, interviews, and classroom observations revealed that the in-service elementary teachers in this study had shifting mathematics perceptions. They had negative perceptions about mathematics and their ability to learn mathematics in elementary and middle school. During college, their perceptions about mathematics shifted toward more positive feelings in that they felt more comfortable learning and teaching mathematics. Overall, their stories of learning mathematics were dominated by negative memories of believing that mathematics was a subject they could not understand. However, both teachers identified situations that changed how they came to understand mathematics and teaching mathematics. This finding is consistent with research literature conducted by Drake (2006) that captured turning point stories of teachers who initially had negative experiences learning mathematics but had experiences that changed their perceptions about mathematics and their ability to learn and teach mathematics. These experiences were evident in the current study as the teachers attributed their early negative perceptions about mathematics to their teachers and classroom activities. However, they were empowered to view themselves as capable mathematics learners and teachers.

This finding brings to light the perceptions individuals have about mathematics. Their ability to learn mathematics can be motivated by the classroom environment. Research literature confirmed that teachers' actions, that is, how they teach mathematics, their speech, and behavior, could influence how their students learn mathematics and promote mathematics anxiety in students (Adeyemi, 2015; Bekdemir, 2010; Gresham, 2018; Unlu et al., 2017). Understanding the impact shifting mathematics perceptions can have on teachers and their students, school districts and administrators could offer support groups and external resources that help teachers discuss and reflect on their thoughts and feelings about mathematics and teaching mathematics. Some teachers do not feel they have the support needed to deal with their mathematics perceptions and teaching experiences (Gresham, 2018). Therefore, there is a need to support teachers in these circumstances.

Findings Related to Anxiety With Complex Mathematics Concepts and Instruction

Individuals may experience MA when presented with higher-level mathematics. This study revealed that both teachers experienced some MA when teaching middle school mathematics and calculating non-academic mathematics. For these teachers, complex mathematics were mathematics concepts higher than elementary mathematics concepts and real-world mathematics such as calculating a discount or tip. When presented with these types of mathematical situations, the teachers described physiological emotions that decreased their confidence about teaching mathematics they did not comprehend.

When teachers avoid complex mathematical concepts, it can affect how they teach these concepts. This avoidance sometimes happens because of their lack of mathematics content knowledge or their inability to recall how they learned the concepts previously (Adeyemi, 2015). Thus, more research is needed to understand teachers' decisions to teach for procedural knowledge and possibly avoiding complex mathematics concepts that focus on depth of understanding. Teachers' avoidance in teaching complex mathematics concepts can affect the number of mathematics concepts students are exposed to and understand, making it challenging for them to understand higher-level mathematics subjects. In essence, mathematics could be straightforward to teach once an individual understands the concepts. If teachers were trained on teaching mathematical concepts, it might increase their confidence in teaching mathematics to students. Thus, teacher preparation programs could provide extended time on mathematics teaching methods and content for middle school concepts. Some teachers only took one middle school mathematics methods course (learning about mathematics pedagogy) and one middle school mathematics content course (focused on mathematical concepts); however, the number of mathematics methods and content courses vary by institution. Some mathematics methods instructors believe that more time is necessary to teach mathematics content and methods courses (Math Methods Instructors, personal communication, April 1, 2021).

These actions on the part of teachers are in accord with Bandura's self-efficacy theory which explained that individuals are more likely to avoid threatening situations that they feel exceed their coping skills and participate in situations they feel more capable of handling. When individuals encounter complicated mathematical concepts, it can be easier for them to avoid learning and understanding the concepts rather than taking the time to persevere and comprehend the concepts. These findings could extent on existing research performed with preservice teachers related to their mathematics content knowledge. Just as the teachers learned elementary mathematics concepts during their college methods courses, they also learned about middle school mathematics concepts. Therefore, mathematics educators who teach mathematics methods courses could check teachers' mathematics knowledge and teaching practices to make sure preservice teachers understand complex mathematics topics. Many preservice teachers did not plan to teach middle school mathematics and only earned grades high enough to pass their mathematics content courses (X. Van Harpen, personal communication, April 1, 2021). Therefore, teacher preparation programs could require students to earn higher grades to pass middle school mathematics content and methods courses. Further, mathematics educators can help support those students individually that struggle to pass these courses.

Teachers who avoid certain aspects of mathematics may not be aware of their avoidance. Hence, it is crucial to conduct more research on this topic to bring more awareness to teachers so they are encouraged to expose themselves to complex mathematics. This exposure can occur through school districts' professional development opportunities related to enhancing elementary teachers' mathematical content knowledge beyond elementary topics. Also, it would be great to develop a mentorship program where elementary teachers can be paired with middle school through college-level mathematics educators to discuss and learn methods for gaining a better understanding of complex mathematical concepts. These suggestions could be more in line with opportunities elementary teachers might be willing to participate in, for some elementary teachers do not desire to take additional mathematics courses (Gresham, 2018).

Findings Connected to Mathematics Anxiety Related to Instruction

An individual's MTSE can be decreased when their MA increases. In this study, teacher's MTSE decreased, and their MA increased when presented with mathematical concepts higher than elementary mathematics. This finding agrees with Unlu et al.'s (2017) study, which determined a negative linear correlation between MA and MTSE. Studies have confirmed that teachers who experience high MA are more likely to have low confidence in their ability to teach mathematics effectively (Swars et al. 2006; Gresham, 2009).

The study's findings indicated one teacher experienced a decrease in her MTSE when presented with student questions. Although she perceived she would welcome students' mathematics questions, this was not the case, for she felt unable to provide students with an answer when they posed questions. During that time, she experienced emotional reactions that indicated a lack of confidence to teach her students. This finding was similar to research literature that stated math-anxious teachers accepted fewer student questions during instruction

(Hadley & Dorward, 2011). This teacher's inability to provide her students with answers to their questions may suggest she lacked the mathematical knowledge needed to understand students' mathematical thinking, or she struggled with explaining said knowledge to students. According to Hughes (2016), teachers must have the adequate mathematical knowledge to acknowledge interesting and relevant mathematical questions. If teachers lack these pedagogical skills of teaching mathematics, the learning environment can become chaotic. Hence, one of the possible reasons there was a lack of student engagement during virtual mathematics instruction. Another point to consider is that the teacher may not prepare herself enough to plan the types of mathematical thinking, problem-solving, or reasoning students might engage in during instruction. This practice is crucial for teachers to foresee potential issues students might have during instruction and decide how to manage them (Superfine, 2008).

The teachers in this study strictly followed the prescribed lesson plans provided to them. These actions were consistent with the research literature on mathematics instruction in urban schools. According to Berry et al. (2015), instruction is prescribed and repetitive in urban classrooms with minimal emphasis on conceptual understanding. In this study, the teachers' use of prescribed lesson plans that were minimally modified could contribute to their increased confidence to teach mathematics since they did not deviate from these plans or design their mathematics lesson plans. Their adherence to prescribed mathematics lesson plans could be manifested in the anxiety they felt when teaching mathematics. Research conducted by Gresham (2009) supported this notion, for teachers in that study were not confident to teach mathematics due to their struggles developing their mathematics lesson plans and teaching those lessons.

To help teachers decrease their MA related to mathematics instruction, they could spend more time on mathematics lesson planning. If teachers are more confident in using prescribed lesson plans, they could use them as a starting point and modify them. These modifications could include problem-solving strategies students might use, conceptual mathematics tasks related to students' lives, and answers for possible student questions. This recommendation supports NCTM's (2000) advice in the types of tasks teachers design should relate to students' real-world experiences that are intriguing, challenging, and can be approached using multiple strategies. School administrators can seek professional development resources on lesson planning that would promote teacher autonomy and freedom to design interactive and engaging mathematics lesson plans. Doing so will help teachers tailor lessons for the population of students they serve. These professional development opportunities could help boost teachers' MTSE and decrease their MA when teaching mathematics.

Findings Associated with Teacher's Confidence Related to Teaching Experience

Longevity is a good indicator of a teacher's confidence to teach an academic subject. The teachers in this study were confident about teaching elementary mathematics due to teaching the same content every year. Their teaching confidence can be understood by subject matter teaching experiences rather than total years of teaching experience in general. Based on Franks' (2017) findings, there is a relationship between self-efficacy and grade level and teaching experience. The current study showed that the teachers' MTSE increased and their MA decreased as they continued to teach 4^{th} and 5^{th}-grade mathematics. As these teachers consistently practiced solving mathematical problems and became knowledgeable with mathematics concepts before introducing them, they gained greater confidence to teach mathematics to their students effectively.

Although the teachers gained the confidence to teach 4^{th} and 5^{th}-grade mathematics based on their teaching experience, this confidence did not translate to higher-level mathematics they were certified to teach. Therefore, for teachers to gain confidence in mathematical concepts they did not typically teach, they could practice teaching higher-level mathematics concepts to become confident. As teachers continue to teach, their confidence in their teaching ability increases, directly influencing their MTSE (Franks, 2017).

Teachers are traditionally assigned to the grade level they teach, and if they are comfortable with that grade level, they usually continue to teach that grade. This situation does not allow teachers to learn how to teach other grade levels of students and become familiar with other mathematical concepts and teach them. Therefore, school districts and administrators could consider changing teaching assignments to allow teachers to gain teaching experience in various grade levels with different students and mathematical concepts. If teachers are uncomfortable with this practice, they could be required to attend training on mathematics concepts they do not usually teach. In the end, teachers should be confident in their ability to teach mathematics effectively as they gain more teaching experience.

Procedural Centered Direct Instruction

The findings from interviews, teacher classroom observations, post-observation interviews, and the fraction simulation task revealed that the in-service elementary teachers in this study overly emphasized procedural mathematics strategies and instruction. Teachers' lessons were filled with procedural mathematics tasks solved using two methods by the teacher with no conceptual understanding or connection to a real-world context. One teacher taught using relational understanding, a pedagogical mathematics teaching strategy that emphasizes the 'why' behind problem-solving procedures. In contrast, the other teacher did not focus on helping students understand the why behind mathematical procedures and strategies. Although the teachers were conceptually minded when discussing their instructional practices and conceptual mathematics tasks were included in their lesson plans, they did not adequately present conceptual mathematics tasks. Students did not discuss the conceptual tasks in context, make sense of the problems, or discuss the strategies used; instead, they solved these tasks procedurally. These practices were more in line with teachers who have low MTSE. According to Zuya et al. (2016), teachers with high MTSE are more likely to attempt new and diverse teaching strategies and are innovative educators. The teachers in this study did not use various teaching strategies and needed more creative ways to teach mathematics virtually.

The teachers often expressed concern about time constraints during interviews, which may have been why their virtual mathematics instruction was enacted procedurally. These teachers' virtual instructional practices went against the mathematics instructional practices recommended by Gadanidis et al.(2002), who suggested that when transitioning to virtual instruction, mathematics content should not be compromised but should encompass rich learning tasks that help develop mathematics concepts. Further, instructional methods should change from students' learning by imitating to students learning conceptually by solving and discussing mathematical concepts through problem-solving and reasoning (NCTM, 2014). The teachers could have provided opportunities to build procedural fluency from conceptual understanding through tasks that promoted reasoning and problem-solving.

Since teaching mathematics virtually was new for many teachers, support is necessary to assist them with implementing face-to-face mathematics instructional practices that are effective. Teachers should modify mathematics content for a virtual environment, and technology is needed to support this transition (Oliver, 2010). Hence, teachers need mathematics-specific professional development to assist with practical ways to adapt and modify mathematics content for virtual instruction. Interactive mathematics programs like Geogebra and Desmos can be included in these professional development sessions to show teachers how to adapt mathematics concepts typically taught during face-to-face instruction.

Findings on the Impact of the Virtual Context on Instructional Practices

This finding was concerned with the online platforms the teachers in this study used to deliver virtual mathematics instruction, an alteration in instructional delivery method, implementation of small groups, and obstacles with mathematics discourse. The teachers in this study utilized various online platforms to deliver virtual mathematics instruction and supplement student learning. The teachers believed the online platforms were suitable for supporting mathematics instruction, student learning, and parent's ability to monitor their child's assignments and communicate with teachers.

Teachers felt uncomfortable allowing students to work in groups on mathematics problems and communicate their mathematical thinking using the online platforms for mathematics instruction. One teacher, in particular, expressed her lack of trust in students working in groups without adult supervision since she was not able to monitor every group at once. Though it may have presented teachers a challenge to divide students into groups using technology, students need social interaction during virtual learning (Gadanidis et al., 2002; Gedeborg, 2016). Further, teachers' lack of trust in students working in groups on math-related activities could mean they have negative beliefs about their students' capabilities to manage their behaviors and work well together. According to McKinney et al. (2009), students of color used computers for basic skill practices while White students used computers for more complex practices in school classrooms. Setting expectations early and holding students accountable are ways teachers can provide students the opportunity to collaborate with their peers.

The absence of student groups eliminated students' chances of engaging in student-centered instruction, nurturing social collaboration, and peer support (NCTM, 2000). When students miss opportunities to work together, it could diminish their mathematics understanding. Often, students understand mathematics concepts by discussing their thinking and problem-solving strategies with their peers. Research literature supports this thought as student collaborations promote participatory and inquiry-based practices that highlight reasoning and problem-solving skills and student discourse (Berry et al., 2009).

The teachers' decision to alter their mathematics instructional practices was contrary to their mathematics teaching and mathematics self-efficacy scale responses. They agreed they would continue to find better ways to teach mathematics; however, their virtual mathematics instruction heavily relied on direct instruction. The issue with this is direct instruction is the most common instructional method used in urban classrooms (McKinney et al., 2007; 2009; Berry et al., 2015). McKinney et al. study stated (2009) 83% of urban elementary teachers often used direct instruction. Further, in urban classrooms, mathematics opportunities are restricted regarding curriculum and instruction, and mathematics teaching methods play an essential role in student performance (McKinney et al., 2009).

Teachers who use direct instruction spend a great deal of time on seatwork, whole-class instruction and cover fewer mathematics concepts (Bekdemir, 2010). These enactments are similar to those carried out by teachers with MA (Gresham, 2018; Hadley & Dorward, 2011; Hughes, 2016, Iyer & Wang, 2013). However, the teachers explained that time constraints were the primary reasons for relying on direct instruction, not MA.

Since time constraints were a significant challenge for the teachers in this study, it would be ideal to research and design rich conceptual mathematics tasks that could be implemented with students in groups. Implementing rich conceptual mathematics tasks will allow students to work on procedural fluency, peer collaboration, and real-world mathematics that is intriguing, challenging, and can be explored using multiple strategies (NCTM, 2000). When teachers use various mathematics instructional practices, students are exposed to more effective and successful teaching practices that allow them to actively participate in the lesson and inspire motivation to understand essential mathematics concepts and the mathematics goals for lessons (Berry et al., 2009). Virtual mathematics instruction could have included interactive student-centered instruction that engaged students in conceptual mathematical tasks. Incorporating some aspects of student-centered instruction is essential so students can reflect and achieve a deep understanding of mathematics (McKinney et al., 2009).

Lastly, the teachers in this study promoted different virtual environments for mathematics discourse. One teacher posed questions to her students that learned in person and the small number of virtual students. The other teacher actively engaged in student discussions during most of the instructional period. However, on some occasions, she minimized students' opportunities to understand the procedures and mathematics concepts. During classroom observations, there were several opportunities where both teachers could have encouraged more student discourse and allowed students to express their mathematical thinking and problem-solving strategies. This is a significant finding for the current study, as no other research studies in the mathematics education literature found that elementary teachers experienced obstacles with mathematics discourse. Through the problem-solving process, students can think, persist, and engage their curiosity and mathematical confidence. According to NCTM (2014), teachers' teaching practices should facilitate meaningful mathematical discourse and pose purposeful questions. These practices are essential skills needed to support deep mathematics understanding.

Findings Related to Virtual Mathematics Teaching Challenges

The teachers in this study faced several challenges teaching mathematics virtually, but their biggest concern was students' behaviors and informal assessment. When students were not actively engaged during instruction, it was challenging to manage effectively, especially when students consistently turned their cameras off or never turned them on. Teachers explained that some students were known to surf the internet during instruction. This situation could explain why some students did not have their cameras turned on. While student cameras were turned off, it was difficult to assess their mathematics understanding. Therefore, teachers could find engaging methods to keep students actively participating in the lesson. Teachers are responsible for engaging students during mathematics instruction (NCTM, 2014). Students can be engaged using technology in a virtual environment because it “enriches the range and quality of investigations by providing a means of viewing mathematical ideas from multiple perspectives” (NCTM, 2000, p. 25). Exposing students to interactive mathematics applications can excite and keep them focused and involved.

As previously stated, dividing students into small groups and implementing real-world conceptual mathematics tasks could be one way to engage students during virtual mathematics instruction. Research literature suggested teachers use student-oriented instruction because it provides students chances to investigate mathematical concepts through exciting and challenging mathematics problems that encourage various approaches and problem-solving strategies to make sense of mathematics tasks (NCTM, 2014). Furthermore, problem-based instruction provides students opportunities to learn mathematics by solving rich conceptual mathematics tasks (King, 2019) that offer students multiple entry points using various tools and representations that aim for high levels of cognitive demand (NCTM, 2014). These conceptual mathematics tasks can be informally assessed using the online program Peak Deck since the teachers expressed its effectiveness for viewing students' work while on screen. The finding related to informal assessment was crucial for this study and adds to current research literature in mathematics education. Although the focus of this was not on informal mathematics assessment, it is important to understand how elementary teachers ensured their students were learning and understanding mathematics using an alternative instructional method.

An implication for teaching practices would be for teachers to research effective online programs that help to informally assess students mathematics learning and understanding. Also teachers could find or design multiple formative assessments that can be used to assess students mathematics learning and understanding as students could be given various ways to express their mathematics understanding other than utilizing traditional testing. Another implication for teaching practices would be for teachers to research online manipulatives to explore, represent, and communicate mathematical ideas. The teachers expressed how often manipulatives were used during face-to-face instruction. Thus it could be beneficial to incorporate online manipulatives or household items that students could use as manipulatives during virtual mathematics instruction. Stutton and Kruger (2002) stated that students use multiple tools as manipulatives to explore mathematics concepts while making sense of these concepts in groups and individually. Further, manipulatives play a vital role in helping students gain a conceptual understanding (McKinney et al., 2007). Hence, teachers can creatively use manipulatives to help students stay engaged in the lesson, reduce students' chances of turning their cameras off, and assess students' mathematics learning and knowledge informally.

Limitations

Due to the COVID-19 pandemic, data collection for this study was conducted virtually. This avenue of data collection impacted the opportunity to observe teachers' mathematics instruction in person, minimizing interactions I observed. I was limited to instructional practices that could be viewed using the virtual platform provided by each teacher. The pandemic also impacted the number of schools and teachers available to participate in this study. Although ten teachers from four schools agreed to participate, two teachers from two schools took part.

Factors that may influence data collection quality were researcher bias related to the construction of interview and post-observation interview questions. To assist with research bias, I ran a series of revisions of these questions, and research experts reviewed them to ensure researcher bias did not influence how the questions were written. However, specific questions came to mind after both sets of interviews were conducted that could have given more insight into teachers' virtual mathematics instruction. A second factor that influenced data collection was the researcher's qualitative interviewing skills. As a novice interviewer, I realized I am still learning the skills needed to probe and dig deeper into interviewees' responses, which could have impacted the level of detail in responses.

Further, I was a co-creator while conducting interviews rather than a passive participant. McGarth, Palmgren, and Liljedahl (2019) stated interviewers are instruments using their abilities, experiences, and competencies during interviews. Consequently, I could have used my knowledge about teaching mathematics virtually more than I did.

A third factor that influenced data collection was the timing of this research study. Due to the transition of instruction to a virtual environment, participant recruitment took longer than expected. This issue impacted the time left in the semester to observe teachers teaching a mathematics concept they felt less confident to teach. Therefore, I had to observe the three lessons teachers were currently teaching. Due to the COVID-19 pandemic, interviews were conducted virtually, which could have impacted the teachers' dispositions when providing responses to interview questions. Further, the researcher and teachers' environments could have affected the answers they offered as there were possible distractions and interference. McGarth et al. (2019) recommended interviews take place in a convenient, comfortable setting free from potential disruptions and noises.

Implications for Practice

These comparative case study results have several implications for teacher preparation programs, school districts, and school administrators.

Teacher preparation programs

This study encourages teacher preparation programs to expose preservice teachers to virtual mathematics instructional practices that consider students' ability levels and learning styles. As it relates to MA and MTSE, if teachers have past negative feelings about mathematics, they could be given a MA survey. If MA emotions exist, mathematics educators could provide methods to help teachers reduce and cope with their MA. Teachers could be reminded that their MA and MTSE levels may influence mathematics instructional decisions in the classroom; therefore, the need to reflect on their MA and MTSE is crucial.

Another area that teacher preparation programs could consider is the cognitive growth of undergraduate students as they enter their teacher preparation programs. Many of these students are recent high school graduates ranging in age from 18–22. This population of individuals are still experiencing cognitive growth and development as adults. As preservice teachers they may need time to revisit math content knowledge with higher levels of abstract thought then what they were exposed to in middle and high school.

School Districts

School districts could encourage teachers to reflect on their mathematics instructional practices and lesson planning to ensure they think about effective methods to engage students in mathematical learning. Also, provide professional development on MA and MTSE as generalized training for all teachers. This way, teachers who may have MA will not feel isolated or uncomfortable learning more about MA and ways to reduce it. As for MTSE, it would be significant for teachers to understand how their confidence in teaching mathematics impacts their instruction and students. Hence, professional development can provide best practices for enhancing teachers' MTSE so those who have low MTSE can increase their MTSE. Teachers who experience MA to the degree that it negatively impacts their instructional choices can be encouraged to embrace professional development opportunities to enhance their current mathematics instructional practices. Teachers have a vital role when educating students in mathematics. Therefore, they are expected to be competent with mathematics skills, have a deep understanding of mathematics, and effectively teach mathematics to students (Boyd et al., 2014). Further, as with teacher preparation programs, school districts can provide professional development on best practices for virtual mathematics instruction tailored toward students' ability levels and learning styles. Not all students learn mathematics at the same rate and using one method of instruction.

School Administrators

Administrators could carefully consider the grade level elementary teachers are assigned. They can first familiarize themselves with experiences teachers have that cause MA, and descriptions teachers might express when speaking about MA and their confidence to teach mathematics. Then administrators can include questions related to MA experiences and teacher confidence in teacher interviews to know if prospective teachers have MA and low confidence in teaching mathematics. Last, future teachers can be assigned to a grade level they have more confidence in teaching. These decisions are important because research literature stated that teachers who experience high MA did not appreciate teaching mathematics; therefore, they will not effectively teach mathematics (Unlu et al., 2017).

This research implies that if we want students' mathematics performance to improve, we need elementary teachers to provide students with teaching experiences that encourage their problem-solving abilities, confidence in, and disposition toward mathematics (NCTM, 2000). It is not enough for teachers to show up and provide one method of instruction but at the same time expect students to have a deep understanding of mathematics. This research showed that alternative instructional methods are essential to increase teachers' MTSE and reduce their MA. Educational stakeholders can assist by providing mathematics professional development opportunities tailored toward mathematics education and instruction.

Future Research

The findings of this study lead to more significant questions and research. Future research could explore how virtual mathematics teaching might enhance face-to-face mathematics instructional practices. It would be interesting to learn how teachers who have taught mathematics virtually incorporate their virtual instructional practices and online platforms into face-to-face instruction to diversify their mathematics instruction. Further, future research could examine how students' mathematics abilities and learning styles were taken into account during virtual mathematics instruction.

The teachers in this study expressed concern about students' mathematics understanding in that their students were learning mathematics differently than in previous years when mathematics instruction was face-to-face. I, too, had a concern about students' mathematics learning and wondered if the students in these teachers' classes comprehended the mathematics concepts and retained the information adequately enough to make connections to mathematics in their everyday lives and other mathematics-related contexts. Future research could explore how students learned mathematics virtually during the COVID-19 pandemic and highlight students' voices to understand how they viewed their mathematics learning, the mathematics concepts they understood and retained, and their teacher's mathematics instructional practices. Further, researching the student perspective could also shed light on the absence of student mathematics discourse and the minimal opportunities students were provided to share their mathematical thinking and problem-solving strategies.

Conclusion

The purpose of this study was to explore mathematics anxiety and mathematics teaching self-efficacy of in-service elementary teachers and how these two constructs might influence these teachers' virtual mathematics instructional practices. This study can contribute to current research in the mathematics education field to help teachers, administrators, mathematics educators, and stakeholders oversee students' mathematics education. The findings can illuminate the minds of elementary teachers who do not necessarily feel math-anxious and are confident about teaching mathematics to examine their mathematics instructional practices to ensure these practices enhance student mathematics understanding and learning. Although teachers could have similar MA and MTSE levels, their mathematics instructional practices might vary based on internal and external factors. While years of teaching experience are a good indicator of a teacher’s high MTSE and low MA, teachers still need to explore alternative teaching methods. These methods should engage students in problem-solving-based instruction to improve students' mathematics performance and mathematical thinking and reasoning.

The virtual instruction context for teaching elementary students is relatively new. That being said, elementary teachers could challenge themselves to explore effective methods to promote and effectively manage small group work. Students need social interaction opportunities using online technology so that they can continue to explore and discuss mathematics how they did during face-to-face instruction. Although virtual mathematics instruction can look different than face-to-face instruction, the outcomes should not differ, and students' mathematics understanding should be the same. Administrators and educational stakeholders should do their best to support elementary teachers' virtual instructional practices by providing mathematics-specific professional development and opportunities to collaborate with other mathematics educators.

I hope that these findings will inspire in-service elementary teachers to consistently examine their mathematics instruction in general and think of interactive and exciting methods to enhance students' mathematics understanding and learning to develop a greater appreciation for mathematics.

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APPENDIX A:

Teacher Invitation Letter

Greetings,

You have been selected as an in-service elementary teacher in an urban school district to participate in a study about elementary teachers' mathematics instructional practices. Through your participation, I hope to understand better how confident and acquainted elementary teachers were as students learning mathematics and their mathematics instructional practices related to implementation. I understand discussing your past with mathematics could be difficult; however, learning more about your experiences can help the mathematics community and educational leaders seek methods to help elementary teachers cope with or alleviate any uncomfortable situations you might have learning about and teaching mathematics to your students.

If you elect to participate in this study, you will be asked to participate in virtual interviews, complete two surveys, virtual class observations, post-observation interviews, and a fraction simulation task. These surveys ask a variety of questions about your experiences learning mathematics and how those involvements shaped the mathematics anxiety and mathematics teaching self-efficacy you might experience; additionally, how these constructs influence your mathematics instructional practices.

Participation is voluntary, and your responses will be kept confidential. The benefits of participating consist of helping teachers realize the need to reflect on their teaching practices and highlight areas of strengths and areas of potential growth. Also, potentially identifying ideal topics for tailoring professional development that can be individualized to teachers' mathematics instruction. Risks to participants are considered minimal, and all information shared will be kept confidential.

If you have any questions or concerns about my study, you may contact me at (414) 467-5680 or at tswope@uwm.edu.

Thank you for your time and input.

Telashay Swope-Farr
Ph.D. student, UWM

APPENDIX B:

Abbreviated Math Anxiety Rating Scale (AMAS)

Directions: Please rate your response to the following statements by placing a mark in one of the boxes for each statement. This survey will take approximately 2-3 minutes to complete. Thank you in advance for completing this survey.

Math Anxiety: Involves nervousness and arousal concerning the manipulation of numbers in academic, private, and social environments.

Statements	Low Anxiety 1	Some Anxiety 2	Moderate Anxiety 3	Quite a bit of Anxiety 4	High Anxiety 5
1. Having to complete a math worksheet by yourself.					
2. Thinking about an upcoming math test one day before.					
3. Watching a teacher work an algebraic equation on the blackboard.					
4. Taking an examination in a math course.					
5. Being given a homework assignment of many difficult problems that is due the next class meeting.					
6. Listening to a lecture in math class.					
7. Listening to another student explain a math formula.					
8. Being given a "pop" quiz in math class.					
9. Starting a new chapter in a math book.					

APPENDIX C:

Mathematics Teaching and Mathematics Self-Efficacy (MTMSE) Scale

TEACHERS BELIEFS AND PERCEPTIONS ABOUT MATHEMATICS TEACHING

This survey will take approximately 10-15 minutes to complete. Your opinions are very important. Thank you in advance for completing this survey.

Part 1: DIRECTIONS: Please use the following scale to answer each question.

1 = Strongly Disagree 2 = Somewhat Disagree 3 = Neither Disagree or Agree

4 = Somewhat Agree 5= Strongly Agree

	Strongly Disagree	Somewhat Disagree	Neither Disagree or Agree	Somewhat Agree	Strongly Agree
1. I will continually find better ways to teach mathematics.					
2. Even if I try very hard, I will not teach mathematics as well as I will most subjects.					
3. I know how to teach mathematics concepts effectively.					
4. I will not be very effective in monitoring mathematics activities.					
5. I will generally teach mathematics ineffectively.					
6. I understand mathematics concepts well enough to be effective in teaching elementary mathematics.					
7. I will find it difficult to use manipulatives to explain to students why mathematics works.					
8. I will typically be able					

	Strongly Disagree	Somewhat Disagree	Neither Disagree or Agree	Somewhat Agree	Strongly Agree
to answer students' questions.					
9. I wonder if I will have the necessary skills to teach mathematics.					
10. Given a choice, I will not invite the principal to evaluate my mathematics teaching.					
11. When a student has difficulty understanding a mathematics concept, I will usually be at a loss as to how to help the student understand it better.					
12. When teaching mathematics, I will usually welcome student questions.					
13. I do not know what to do to turn students on to mathematics.					

Part 2: Directions: Please rate the following mathematics topics according to how confident you would be teaching elementary students each topic.

Please use the following scale.

1 = Not Confident at All 2 = Slightly not Confident 3 = Neither Unconfident or Confident

4= Average Confidence 5=Completely Confident

	Not Confident at All	Slightly not Confident	Neither Unconfident or Confident	Average Confidence	Completely Confident
1. Averages, Mean, Median & Mode					

	Not Confident at All	Slightly not Confident	Neither Unconfident or Confident	Average Confidence	Completely Confident
2. Multiplication					
3. Number Patterns					
4. Shape Properties					
5. Fractions					
6. U.S. Customary Measurement System (e.g.feet, pounds, gallons)					
7. Probability					
8. Decimals					
9. Order of Operations					
10. Metric System (e.g. meters, liters, grams)					
11. Division					
12. Perimeter & Area					
13. Tables & Graphs					

Part 2 cont.: Directions: Please rate the following statements according to how much you agree or disagree. Please use the following scale:

1 = Strongly Disagree 2 = Somewhat Disagree 3 = Neither Disagree or Agree

4 = Somewhat Agree 5= Strongly Agree

	Strongly Disagree	Moderately Disagree	Neither Disagree or Agree	Moderately Agree	Strongly Agree

	Strongly Disagree	Moderately Disagree	Neither Disagree or Agree	Moderately Agree	Strongly Agree
1. Developing speed and accuracy of math skills improves understanding.					
2. I encourage students to use manipulatives to explain their mathematical ideas to other students.					
3. I put more emphasis on getting the correct answer than on the process followed,					
4. The teacher's primary role is to carefully demonstrate new math problems to students.					
5. When introducing math topics which I am confident teaching, it is important to first build understanding of a concept before focusing on algorithms.					
6. I like my students to master basic mathematical operations before they tackle complex problems.					

	Strongly Disagree	Moderately Disagree	Neither Disagree or Agree	Moderately Agree	Strongly Agree
7. When two students solve the same problem correctly using two different strategies I have them share the steps they went through with each other.					
8. I frequently ask my students to explain why something works.					
9. Formulas and rules should be presented first when introducing new topics.					
10. A lot of things about mathematics must simply be accepted as true and remembered.					
11. When teaching a topic which I am less confident teaching, if I start with the process students will come to understand the concept.					
12. With topics I am more confident teaching, I am more likely to explore alternative teaching strategies.					

Part 3: Demographics

1. What is your gender? ________________________

2. What is your race?
   a. Black/African American
   b. Asian
   c. Hispanic
   d. White
   e. Two or more races
   f. Other:_______________________________

3. How many years have you been teaching?

   0–2 3–5 6–10 11–15 16–20 21–30 30+

   a. How many years of experience teaching mathematics? ________________

4. What is your highest level of degree earned?
   a. Associate
   b. Bachelors
   c. Maters
   d. Doctorate

5. What was your major in college? _______________________________________

6. What type of teaching license do you hold? Circle all that apply.

   a. Type: Emergency License Provisional License Lifetime License

   b. Grades: Pre–K K 1 2 3 4 5 6 7 8

7. Circle all subjects that you teach
   a. Language Arts
   b. Mathematics
   c. Reading
   d. Science
   e. Social Students

8. What subject are you <u>most</u> confident teaching in an elementary school?
   a. Language Arts
   b. Mathematics
   c. Reading
   d. Science
   e. Social Students

9. What subject are you least confident in teaching in an elementary school?
    a. Language Arts
    b. Mathematics
    c. Reading
    d. Science
    e. Social Students

10. Which of the 13 mathematics topics from page 2 of the survey are you most confident teaching?

11. Which of the 13 mathematics topics from page 2 of the survey are you least confident teaching?

Please keep in mind that all answers will be kept strictly confidential. So that I may contact you for a possible follow-up interview, please provide this information:

Name ____

School ___________________________________ Grade ________

e-mail address _____________________________ Phone number _______________________

Thank you very much for your participation in my study!

Survey Number __________

APPENDIX D:

Mathematics Lesson Plan Rubric

Components	1	2	3
Student Engagement	Is not present or hardly connects to the lesson objective(s) and no connection to real world context or students' lives.	A hook is used connected to the lesson that grabs students' attention, visuals or artifacts are connected to real world context or students' lives.	Creatively hooks the students' attention to the lesson by incorporating interesting visuals or artifacts that are strongly connected to a real-world context or students' lives.
Mathematical Tasks	Tasks planned for are procedural in nature, no contextualization or promotion of student thinking, reasoning or justifying is not evident. Tasks lack opportunity for differentiation.	Tasks planned for are procedural in nature, however, some effort is made to promote conceptual understanding. Contextualization or promotion of student thinking, reasoning or justifying is evident. Tasks show minimal evidence for adaptations to enhance student learning.	Tasks designed promote conceptual understanding tied to real-world context and/or students' lives. Tasks encourage student thinking, reasoning, justifying and problem-solving. Task were designed to have multiple paths to solutions or multiple solutions.
Questioning/Class Discussions	Mathematical questions are not planned for by teacher. Opportunities for students to pose questions to the teacher and discuss their work and thinking with other students were not planned for.	Low level mathematical questions were planned by teacher. Teacher allocated minimal opportunities for students to pose questions to the teacher and other students. Minimal class discussions were planned.	Teacher prepared a mixture of high-and low-level questions to advance student reasoning and sense making to build on student thinking to promote conceptual understanding. Teacher planned multiple opportunities for class discussions and student questions.
Lesson Timing	Time planned for mathematical activities and tasks were minimized or not evident in the lesson plans. Time for student groups was not evident. Overall time allocated for mathematics lessons was shorter than one hour.	Time allocated for mathematical activities and tasks were less than 45 minutes. Time allocated for student groups based on students' abilities was evident in the lesson plan.	The teacher allocated 45 mins to one hour for mathematics activities and tasks. Multiple opportunities for students to work in groups was planned and an appropriate amount of time was allocated based on students' abilities.

APPENDIX E:

Mathematics Classroom Observation Protocol for Practices (MCOP^2)

1) Students critically assessed mathematical strategies. (4)

Score	Description	Comments
3	More than half of the students critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher.	
2	At least two but less than half of the students critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher.	
1	An individual student critically assessed mathematical strategies. This could have happened in a variety of scenarios, including in the context of partner work, small group work, or a student making a comment during direct instruction or individually to the teacher. The critical assessment was limited to one student.	
0	Students did not critically assess mathematical strategies. This could happen for one of three reasons: 1) No strategies were used during the lesson; 2) Strategies were used but were not discussed critically. For example, the strategy may have been discussed in terms of how it was used on the specific problem, but its use was not discussed more generally; 3) Strategies were discussed critically by the teacher but this amounted to the teacher telling the students about the strategy(ies), and students did not actively participate.	

2) The lesson involved fundamental concepts of the subject to promote relational/conceptual understanding. (6)

Score	Description	Comments
3	The lesson includes fundamental concepts or critical areas of the course, as described by the appropriate standards, and the teacher/lesson uses these concepts to build relational/conceptual understanding of the students with a focus on the "why" behind any procedures included.	
2	The lesson includes fundamental concepts or critical areas of the course, as described by the appropriate standards, but the teacher/lesson misses several opportunities to use these concepts to build relational/conceptual understanding of the students with a focus on the "why" behind any procedures included.	
1	The lesson mentions some fundamental concepts of mathematics, but does not use these concepts to develop the relational/conceptual understanding of the students. For example, in a lesson on the slope of the line, the teacher mentions that it is related to ratios, but does not help the students to understand how it is related and how that can help them to better understand the concept of slope.	
0	The lesson consists of several mathematical problems with no guidance to make connections with any of the fundamental mathematical concepts. This usually occurs with a teacher focusing on procedure of solving certain types of problems without the students understanding the "why" behind the procedures.	

3) The lesson promoted modeling with mathematics (7)

Score	Description	Comments
3	Modeling (using a mathematical model to describe a real-world situation) is an integral component of the lesson with students engaged in the modeling cycle (as described in the Common Core State Standards).	
2	Modeling is a major component, but the modeling has been turned into a procedure (i.e. a group of word problems that all follow the same form and the teacher has guided the students to find the key pieces of information and how to plug them into a procedure.); or modeling is not a major component, but the students engage in a modeling activity that fits within the corresponding standard of mathematical practice.	
1	The teacher describes some type of mathematical model to describe real-world situations, but the students do not engage in activities related to using mathematical models.	
0	The lesson does not include any modeling with mathematics.	

4) The lesson provided opportunities to examine mathematical structure (symbolic notation, patterns, generalizations, conjectures, etc). (8)

Score	Description	Comments
3	The students have a sufficient amount of time and opportunity to look for and make use of mathematical structure or patterns.	
2	Students are given some time to examine mathematical structure, but are not allowed adequate time or are given too much scaffolding so that they cannot fully understand the generalization.	
1	Students are shown generalizations involving mathematical structure, but have little opportunity to discover these generalizations themselves or adequate time to understand the generalization.	
0	Students are given no opportunities to explore or understand the mathematical structure of a situation.	

5) The lesson included tasks that have multiple paths to a solution or multiple solutions. (9)

Score	Description	Comments
3	A lesson which includes several tasks throughout; or a single task that takes up a large portion of the lesson; with multiple solutions and/or multiple paths to a solution and which increases the cognitive level of the task for different students.	
2	Multiple solutions and/or multiple paths to a solution are a significant part of the lesson, but are not the primary focus, or are not explicitly encouraged; or more than one task has multiple solutions and/or multiple paths to a solution that are explicitly encouraged.	
1	Multiple solutions and/or multiple paths minimally occur, and are not explicitly encouraged; or a single task has multiple solutions and/or multiple paths to a solution that are explicitly encouraged.	
0	A lesson which focuses on a single procedure to solve certain types of problems and/or strongly discourages students from trying different techniques.	

6) The lesson promoted precision of mathematical language. (10)

Score	Description	Comments
3	The teacher "attends to precision" in regards to communication during the lesson. The students also "attend to precision" in communication, or the teacher guides students to modify or adapt non-precise communication to improve precision.	
2	The teachers "attends to precision" in all communication during the lesson, but the students are not always required to also do so.	
1	The teacher makes a few incorrect statements or is sloppy about mathematical language, but generally uses correct mathematical terms.	
0	The teacher makes repeated incorrect statements or incorrect names for mathematical objects instead of their accepted mathematical names.	

7) The teacher's talk encouraged student thinking. (11)

Score	Description	Comments
3	The teacher's talk focused on high levels of mathematical thinking. The teacher may ask lower level questions within the lesson, but this is not the focus of the practice. There are three possibilities for high levels of thinking: analysis, synthesis, and evaluation. ***Analysis*** : examines/ interprets the pattern, order or relationship of the mathematics; parts of the form of thinking. **Synthesis**: requires original, creative thinking. **Evaluation**: makes a judgment of good or bad, right or wrong, according to the standards he/she values.	
2	The teacher's talk focused on mid-levels of mathematical thinking. **Interpretation**: discovers relationships among facts, generalizations, definitions, values and skills. **Application**: requires identification and selection and use of appropriate generalizations and skills	
1	Teacher talk consists of "lower order" knowledge based questions and responses focusing on recall of facts. **Memory**: recalls or memorizes information. **Translation**: changes information into a different symbolic form or situation.	
0	Any questions/ responses of the teacher related to mathematical ideas were rhetorical in that there was no expectation of a response from the students.	

8) There was a climate of respect for what others had to say. (13)

Score	Description
3	Many students are sharing, questioning, and commenting during the lesson, including their struggles. Students are also listening (active), clarifying, and recognizing the ideas of others.
2	The environment is such that some students are sharing, questioning, and commenting during the lesson, including their struggles. Most students listen.
1	Only a few share as called on by the teacher. The climate supports those who understand or who behave appropriately. Or Some students are sharing, questioning, or commenting during the lesson, but most students are actively listening to the communication.
0	No students shared ideas.

Comments

9) The teacher uses student questions/comments to enhance conceptual mathematical understanding. (16)

Score	Description
3	The teacher frequently uses student questions/ comments to coach students, to facilitate conceptual understanding, and boost the conversation. The teacher sequences the student responses that will be displayed in an intentional order, and/or connects different students' responses to key mathematical ideas.
2	The teacher sometimes uses student questions/ comments to enhance conceptual understanding.
1	The teacher rarely uses student questions/ comments to enhance conceptual mathematical understanding. The focus is more on procedural knowledge of the task verses conceptual knowledge of the content.
0	The teacher never uses student questions/ comments to enhance conceptual mathematical understanding.

Comments

Additional Notes:

Date: ______________ School: _______________________ Teacher: ____________________

Number of Students: ___________________

Topic/Subject: ____

APPENDIX F:

Interview Protocol

Questions to establish comfortability with study

a) One of my best mathematics experiences as a student was.....

b) One of my most challenging experiences as a mathematics student was...

Interview questions

1. Why did you choose to teach the current grade you are teaching?
2. What is your level of understanding of 4th and 5th-grade mathematics?
   a. How do you determine this understanding?
3. What are your feelings about mathematics? Why?
4. What curriculum do you use?
   a. What are your thoughts about this curriculum?
   b. Do you adapt or supplement mathematics tasks and or design your own tasks?
5. Do you believe you have mathematics anxiety? Why or why?
   a. Explain a time when you felt mathematics anxiety.
   b. You speak about MA; how does it show up during instruction?
   c. I think anxiety and or low confidence in mathematics is caused by...
6. How confident are you to effectively teach mathematics?
7. How confident and skilled are you to teach mathematics virtually?
8. What skills and training do you have to deliver mathematics instruction virtually?
9. How did you adjust mathematics instructional materials going into a virtual teaching environment?

10. What platforms and tools do you use to deliver mathematics virtually (Google classroom, Zoom, Khan academy, Google forms, etc)?

11. Was there any mathematics instructional or content-related sacrifices that had to be made to move to virtual instruction?

12. A time when I feel unsure about teaching mathematics is when...

13. When I am planning my weekly mathematics lessons, and I come to a content area that I love I…

14. When I am planning my weekly mathematics lessons, and I come to a content area that I am unsure about I…

15. If my students do not understand a mathematical concept that I am teaching I...

16. What types of instructional teaching techniques do you use to teach mathematics (engagement, groups, whole class)?

    a. Are these techniques effective? Why or why?

17. During instruction, do you show or discuss multiple strategies for arriving at a solution as well as recognize and address incorrect strategies and answers? Why or why not?

18. What are the most important aspects of teaching and motivating students to learn mathematics (hands-on opportunities, real-world experiences, problem-solving situations, etc.)?

19. Are mathematics professional development opportunities offered at your school?

    a. If so, do you attend? Why or why not?

    b. If not, how do you improve and extend your mathematics abilities?

20. How has MA, MTSE affected you personally and professionally?

APPENDIX G:

Post-Observation Interview Protocol

1. How did you feel mathematics instruction went today?
    a. How did things compare with what you expected during planning?
    b. Were you surprised by anything?
    c. Was there anything you were pleased about? What? Why?
    d. Were you disappointed or upset about anything? What? Why?

2. Did any of the instructional techniques you attempted work well with the students?
    a. Did you feel any frustration while teaching? If so, why?
        i. Did you notice frustration from students?
            1. If so, what do you think caused that frustration?
            2. Did students provide any feedback related to your instructional methods?
    b. If more than one technique was attempted, which do you feel worked best? Why?

3. Was there any content in this lesson that you felt was challenging for you to teach? Why or Why not?

4. How was your experience planning and teaching mathematics virtually?

    Probes
    a. Were there any modifications to the lesson or content that did/did not work with the transition?
    b. How effective/ineffective were the online platforms for mathematics instruction?

5. I notice the students were/were not divided into groups. Why or Why not?
    a. If in groups, how were they formed?
    b. If no groups, how often do students work in groups?

6. Was this lesson typical of how you normally teach mathematics?
    a. If yes, was anything done special since you were being observed?
    b. If no, how was today's instruction different than usual?

7. I noticed:
    This space is for anything I found curious during the observation.

8. Is there any other information you would like to share about your mathematics instruction from the lesson I observed?

APPENDIX H:

Fraction Mathematics Task-Teacher Approach to Instruction

Filling Beauty's Seats

Standards

Grade 4: Number & Operations - Fractions Extend understanding of fraction equivalence and ordering. Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers.

Grade 5: Number & Operations - Fractions Use equivalent fractions as a strategy to add and subtract fractions.

Mathematical Practices: 1. Make sense of problems and persevere in solving them. 2. Reason abstractly and quantitatively. 3. Construct viable arguments and critique the reasoning of others

The Problem:

Filing Beauty's Seats Tickets to Fairview Elementary School's production of Beauty and the Beast went on sale this week. The school theater has 24 rows of 16 seats each.

1/3 of all the seats have been sold to students for $3 each.

1/4 of them have been sold to adults for $5 each.

1/6 of them were given to the teachers.

1. If everyone who already has a ticket goes to the show, what fraction of the seats in the theater will be filled?

2. How many seats are still available?

Extra: How much money has been collected so far? If all the remaining seats are sold to students, how much money will be raised altogether?

Questions

1. Now that you have reviewed the mathematics task above, how would you approach teaching/exploring this task with students?
2. Is there any additional mathematics knowledge that you feel is needed, or you would include to effectively teach this task to students?

Interview follow up questions

1. How would you compare students' learning and understanding of mathematics concepts in a virtual setting to an in-person setting?
    a. Are students understanding mathematics the same or differently? Why or Why not.

2. I noticed that you only spoke about your mathematics anxiety if you had to teach a higher grade.
    a. Explain what that mathematics anxiety would feel/look like.
    b. Explain your confidence in teaching a grade other than 4^{th} or 5^{th}.
3. How do you feel about completing math-related tasks other than teaching mathematics to students?

CURRICULUM VITAE

Telashay Swope-Farr

Place of Birth: Mt. Clemens, MI

Education:

B.S., Rust College, April 2005

Major: Mathematics

M.S., University of Wisconsin-Milwaukee, December 2007

Major: Curriculum & Instruction

Dissertation Title: Examining Virtual Mathematics Instruction: A Case Study of In-Service Elementary Teachers with Mathematics Anxiety and Mathematics Teaching Self-Efficacy

Honors/Awards:

Ronald E. McNair Scholar, Rust College 2003-2005

Innovative Teacher, Milwaukee Public Schools-Vincent High School 2012

Emerging Leader, Milwaukee Public Schools-Vincent High School 2013

Metropolitan Milwaukee Alliance of Black Schools Educator, Milwaukee Public Schools-Vincent High School 2014

Mathematics Teacher of the Year, Milwaukee Public Schools-Vincent High School 2014

Most Valuable Teacher, Milwaukee Public Schools-Vincent High School 2015

Pi Lambda Theta-National Honors Society, University of Wisconsin-Milwaukee 2018

Chancellor’s Award, University of Wisconsin-Milwaukee 2020

Teaching Experience:

Secondary School Teacher, Maasai Institute 2006-2008

Secondary School Teacher, Milwaukee Public Schools 2008-Present

Mathematics Instructor, University of Phoenix 2008-2009

Mathematics Instructor, Bryant & Stratton	2009-2011
Secondary School Teacher, UW-Madison P.E.O.P.L.E Program	2012-Present
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Presentations:

American Educational Research Association Annual Meeting Division B Paper and Symposium Session Presenter	April 2021