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The Impact of Elementary Mathematics Coaches on Elementary Teachers' Attitudes Towards Teaching Mathematics

Samuel R. Ward
University of Maine, samuel.ward@maine.edu

THE IMPACT OF ELEMENTARY MATHEMATICS COACHES ON ELEMENTARY TEACHERS' ATTITUDES TOWARDS TEACHING MATHEMATICS

By

Samuel R. Ward

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Advisory Committee:

Janet Fairman, Associate Professor of Education, Co-Advisor

Franziska Peterson, Assistant Professor of Mathematics, Co-Advisor

Eric Pandiscio, Associate Professor of Mathematics Education

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By Samuel R. Ward
Thesis Advisors: Janet Fairman and Franziska Peterson

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This study compares levels of mathematics anxiety and teacher efficacy between inservice and preservice elementary teachers. Prior research has indicated that mathematics anxiety is a common trait among elementary teachers. Mathematics anxiety has also been found to have a negative impact on preservice elementary teachers' efficacy towards teaching mathematics. To address this challenge, some states have begun hiring elementary mathematics coaches to support elementary teachers. Besides focusing on mathematics anxiety and teacher efficacy, this study also investigated the impacts of elementary mathematics coaches on inservice elementary teachers.

A total of 174 inservice teachers and 51 preservice teachers completed a survey comprised of the Revised Mathematics Anxiety Rating Scale and the Mathematics Teacher Efficacy Beliefs Instrument. Survey data were analyzed by using two-sample t-tests that revealed that preservice elementary teachers reported significantly higher levels of mathematics anxiety than inservice elementary teachers. Additionally, the analysis revealed that the inservice teachers reported significantly more efficacy towards teaching mathematics than the preservice teachers. This study also found that working with mathematics coaches had positive impacts on inservice teachers' mathematics anxiety and mathematics teacher efficacy. Open-ended questions were analyzed by open coding techniques and revealed that teachers reported co-teaching, co-planning, curriculum and content support to be the most beneficial forms of interaction with the coaches. This study addresses a gap in the literature by comparing the levels of mathematics anxiety and teacher efficacy in inservice and preservice elementary teachers. Additionally, the results of this study expand our knowledge of the relationship between mathematics anxiety and mathematics teacher efficacy, as well as the impact of elementary math coaches. The findings have implications for the preparation of preservice elementary teachers and provide direction for further research on the impacts of elementary mathematics coaches.

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As school districts around the United continue hiring mathematics coaches (Grant & Davenport, 2009) the need for research on the impacts of these coaches grows. This study investigates how mathematics coaches impact elementary teachers' mathematics anxiety and mathematics teacher efficacy. Similarly, little is known about the levels of mathematics anxiety and mathematics teacher efficacy. This study attempts to fill that gap by comparing the levels of mathematics anxiety and teacher efficacy in inservice and preservice elementary teachers.

Students in the United States traditionally perform worse on international tests compared to students in other countries. According to "The Nation's Report Card" (2019), only 42% of Maine fourth graders score at or above proficiency on standardized mathematics tests. In addition to a large proportion of students struggling with mathematics, a high percentage of elementary teachers do not believe that they have the ability to teach mathematics adequately (Bursal & Paznokas, 2006). Yet the mathematics learned during the elementary school years is crucial in helping students develop the fundamentals needed for success in mathematics beyond elementary school (Edwards, Maloy, & Anderson, 2009). Not only do teachers lack understanding of the fundamentals themselves, they also lack an understanding of how students learn these fundamentals, and thus how to teach them effectively (Ford & Strawhecker, 2011). Further, many elementary teachers themselves experience feelings of anxiety towards mathematics. Unfortunately, many of the same anxieties surrounding mathematics learning can transfer into their teaching of mathematics (Harper & Daane, 1998).

In response to the aforementioned issues, schools and districts around the country have sought to hire mathematics coaches (Mangin, 2007). The goal of hiring a mathematics coach (other times referred to as a mathematics specialist, teacher leader, or support teacher), is to provide teachers with an on-site resource who is well versed in mathematics content knowledge and pedagogical knowledge (Campbell & Malkus, 2011). The mathematics coach also provides teachers with more opportunities for collaboration, as well as feedback from observation (Neufeld & Roper, 2003). Coaching, as opposed to other professional development opportunities, allows for more personalized and consistent interaction between the coach and the teacher (Hill, Bicer, & Capraro, 2017). If research can provide more empirical evidence of the positive impact of mathematics coaching on teachers, teaching practices and student learning outcomes, then even more school and district leaders may be convinced to find the funding to provide mathematics coaches for their teachers (Drust, 2015).

The Maine Mathematics Coaching Project (MMCP) was established at the University of Maine Farmington in 2015 to support preK-8 teachers as they transition into the role of elementary mathematics coaches and to build capacity statewide with a cadre of trained mathematics coaches who could work with teachers to improve mathematics achievement on a broader scale The MMCP is the only program in Maine that prepares mathematics coaches, and one of the few in the nation that requires both the teacher and their school administrators to participate (Macarthur, 2017). The program requires a two-year commitment from the coaching candidate and the school district in which the candidate currently works. The candidate must have a Maine Teaching Certificate in either early childhood, K-3, K-8, or 7-12 mathematics, in addition to a minimum of three years of teaching experience at the PreK-8 level. It is also recommended by the program that the coaching candidate have a master's degree or is currently pursuing a master's degree. With four summers of implementation, the program has trained 26 teachers to become mathematics coaches, many of whom have returned to their districts to take on this new role.

This manuscript describes a research study that investigates the impact of elementary mathematics coaches on elementary teachers' mathematics anxiety and mathematics teacher efficacy. Additionally, this study compares the levels of mathematics anxiety and mathematics teacher efficacy between inservice and preservice elementary teachers. In the following chapters, I will summarize the literature that informed my study, the methods I applied to carry out the study, my analysis of the data, and finally, a discussion of the results.

Chapter 2: LITERATURE REVIEW

The following sections provide a review of the existing literature on the instructional coaching, elementary mathematics teachers, mathematics anxiety, gender and mathematics anxiety, and self-efficacy. Mathematics anxiety, both in students and teachers, is a prominent theme of this study. Mathematics anxiety is one of the major reasons why many students struggle with mathematics (Ashcraft & Kirk, 2001), so it is important to understand why mathematics anxiety occurs, and how it affects students' mathematics thinking and performance.

Another important theme is self-efficacy in teachers. While self-efficacy and math anxiety are different constructs, the research indicates that both are related, and can have large impacts on teaching practice. The following sections will highlight the relationship between math anxiety and self-efficacy.

In addition to reviewing the literature on math anxiety and teacher efficacy, the following section will provide a review of prior research on professional development for teachers. The literature involving evidence on which forms of professional development, including coaching, have proven to be most effective for teachers, will also be reviewed. Lastly, previous research that is specific to mathematics coaching and coaching implementations around the United States will be highlighted.

Math Anxiety and Self-Efficacy

Mathematics anxiety refers to the feeling of discomfort that arises when faced with mathematics tasks that are seen as threatening to one's self-esteem, and affects over 90% of Americans in some way (Blazer, 2011; Trujillo & Hadfield, 1999). A 2014 study highlighted many of the common sources of mathematics anxiety in preservice elementary teachers, such as an emphasis on basic skills, strict adherence to the curriculum, an authoritarian teaching style, an emphasis on correct answers, individual work, and an emphasis on rule-bound procedures (Finlayson, 2014). The study involved interviewing 70 preservice teachers to better understand the sources of their own mathematics anxieties. Among this group, the three most frequently reported causes of mathematics anxiety were teaching style, students' lack of knowledge, and lack of self-confidence. Traditional mathematics teaching practice may not allow much time for discussion between teacher and student, or for student reflection, activities that support student learning and understanding (Van de Walle, 2004). Instead of employing active learning techniques, the traditional style often places far too much emphasis on memorization and rote calculations (Cates & Rhymer, 2003). This style of teaching also turns mathematics into a high-risk activity, one where it is imperative that students find the correct answer in a timely fashion (Geist, 2010). With such an emphasis placed on the correct answer, fear of failure in students can become a strong source of mathematics anxiety (Finlayson, 2014). Further, it is common for teachers to have a general approach to instruction, teaching as though all students have the same initial mathematics knowledge, abilities and learning styles (Boaler, 2002). If teachers do not adapt their instructional approaches to account for variation in students' prior knowledge, their instruction may be less effective for some students.

The results of a 2018 study suggest that students with higher levels of mathematics anxiety show lower numerical intelligence, in addition to other specific mathematics deficits (Schillinger et al., 2018). Some people would then infer that mathematics-anxious students may be simply less competent mathematics students. However, while mathematics anxiety and mathematics competency are typically inversely related, what is happening in the brain of the anxious mathematics student is much more complex (Beilock, 2008).

In some students, mathematics anxiety can produce minor frustrations. However, in others, mathematics anxiety can cause an overwhelming emotional and physiological reaction (Ashcraft & Moore, 2009). Students' fear of doing mathematics often outweighs their actual ability to do mathematics in terms of factors influencing a students' success (Beilock et al., 2010). Thus, the research suggests that a students' mathematics anxiety is a crucial variable that affects mathematics achievement (Soni & Kumari, 2017).

When a student becomes anxious in a mathematics setting, it can be very hard to focus on the task at hand. The mathematics problem causes the student to worry, which in turn creates thoughts that distract the student and decrease his or her working memory capacity (Justicia-Galiano et al., 2017). The research has supported this idea, showing that working memory capacity is negatively associated with mathematics anxiety (Ashcraft & Kirk, 2001). Essentially, when a student starts to worry while working on a mathematics problem, they have effectively handicapped themselves. Their worry has made what was already a potentially difficult task, into a much more daunting challenge. Students are unable to block out irrelevant information and thoughts to focus on the outcome of the task at hand. Researchers refer to this effect as the *distraction account* of failure, due to the stressful nature of mathematics putting students in a dual-task situation, where the ability to solve the problem and the worry that mathematics evokes are now competing for the brain's working memory capacity (Beilock, 2008). Unfortunately, these students are at the mercy of their own worries and negative thoughts when it comes to learning mathematics. This handicap that students must deal with has led researchers to propose that mathematics anxiety functions like a learning disability, in that it leads to negative personal, educational, and cognitive outcomes for students (Ashcraft & Moore, 2009).

Further, mathematics anxiety has been found to influence self-concept in students, which can then affect students' motivation to learn mathematics or to truly challenge themselves as mathematics students. If a student already thinks that he or she is bad at mathematics, or in other words, has a negative self-concept in terms of mathematics, there is an increased likelihood that that student will avoid mathematics as much as possible, thus impairing that student's performance (Justicia-Galiano et al., 2017). Alternatively, one could argue that a student with mathematics anxiety, but a positive self-concept, would put in extra effort to make up for the deficit created by their mathematics anxiety. Other personality traits, such as a lack of self-esteem, shyness, and an inability to manage anger and frustration can also contribute to one's anxiety towards mathematics (Blazer, 2011).

Many other factors can contribute to a student's mathematics anxiety. In Serbia, a study indicated that mathematics anxiety was a systemic issue, rather than an issue of individual students. One could claim that similar indicators would arise in countries where traditional teaching styles are common, and standardized tests are held in high regard, such as the United States (Radišić et al., 2015). A student's home life can also play a role in his or her mathematics anxiety as well. Some research has shown that a parent's views towards mathematics can affect how that student views mathematics. Parents who place extreme pressure on their students to succeed risk negatively impacting the student's conceptual development, self-efficacy in the classroom, and overall school achievement (Puklek Levpušček & Zupančič, 2009). Also, studies show that a parent's mathematics anxiety can be positively correlated with a student's mathematics anxiety, while also having a negative effect on a student's attitude towards mathematics. Thus, students are more likely to experience mathematics anxiety if his or her parent(s) experienced mathematics anxiety as well (Soni & Kumari, 2017).

Gender and Mathematics Anxiety

There is also ample research reporting on the influence of gender on students' attitudes towards mathematics. Stereotype threat refers to one performing poorly in situations where that person is cognizant of negative stereotypes about how someone with the same social makeup should perform (Beilock, 2008). In other words, when a student thinks he or she is expected to perform worse than their peers, that student is more likely to perform poorly. Women are particularly susceptible to the negative consequences of stereotype threat in mathematics. Women are at risk of stereotype threat when they think that their own performance may confirm the negative stereotypes about women in mathematics, or the worry that their performance represents females in a negative way (Shapiro & Williams, 2011).

Past research has indicated that stereotype threat can have a negative effect on female students' self-efficacy and performance on mathematics tests (Spencer et al., 1999). Because of historical social norms, females are less likely to be encouraged to pursue a career in STEM fields, which can result in a decrease in females' mathematics self-efficacy. This, in turn causes females to underestimate their mathematical potential, and potentially avoid mathematics as much as possible (Betz, 2004). Other research has indicated that students with higher self-efficacy towards a subject are more likely to remain engaged and interested in a subject, which can lead to positive student outcomes (Bandura et al., 2001).

Another study found that when female students were asked to provide their gender prior to the AP Calculus exam, their exam scores decreased by 33% compared to those who were asked to report their gender after the test (Danaher & Crandall, 2008). Additionally, there is evidence that girls in mathematics class experience far less enjoyment and pride when compared to boys (Frenzel et al., 2007). Other research indicates that boys have a better chance of adapting to the traditional, authoritative style of teaching when compared to girls (Boaler, 2002).

In addition to stereotype threat, there are other factors that can lead to a decrease in mathematics achievement for females. The results of one study, comprised of 205 undergraduate students indicated that the female students had higher levels of mathematics anxiety, which caused a deficit in their visuo-spatial working memory, which resulted in poor performance on mathematics assessments (Ganley & Vasilyeva, 2014). Another study supported this, indicating that female students are consistently more anxious during mathematics tests than male students (Miller & Bichsel, 2004). As female students perceive socially-biased expectations for their mathematics performance, this produces anxiety that in turn reduces their performance on mathematics tests, and unfortunately reinforces the common notion that men are better than woman at mathematics (Beilock et al., 2010). Given that 76% of public school teachers in the US are female (*Fast Facts*, 2018), the gender bias of mathematics anxiety has strong implications for women who choose to become school teachers.

Preservice Elementary Teachers and Mathematics Anxiety

The preceding discussion of the research literature addressed some of the causes associated with feelings of anxiety that mathematics triggers for many students, and to a larger extent for girls or women than for boys or men. Once these negative feelings start to dominate a student’s attitude towards mathematics, it can be very hard to reverse. The result is that a student may deal with these mathematics anxieties throughout the rest of his or her school career. This can mean dreading every successive mathematics class they have to take, while battling with their anxieties all year to just do well enough to pass (Harper & Daane, 1998). And for many students, this may mean choosing a college major that requires the least mathematics credits to graduate.

As noted earlier, many preservice elementary school teachers themselves suffer from mathematics anxiety due to their experiences as younger students. In many cases, these preservice teachers can trace their anxious feelings back to teachers who saw mathematics procedures as trivial and intuitive (Cornell, 1999). Their anxiety may have stemmed from bad experiences in the classroom, pressure from parents, teachers who were unaware of student feelings, the traditional manner with which mathematics is taught, and classroom cultures that did not encourage student participation. In addition to these external factors, internal factors such as negative attitude, shyness, low self-esteem, and a view of mathematics as a male-dominated subject have also caused mathematics anxiety in preservice elementary teachers (Trujillo & Hadfield, 1999). Some research also suggests that more often than not, preservice elementary school teachers' mathematics anxiety stems from bad experiences in the K-12 classroom, and not from bad experiences with real world mathematics (Burton, 2012).

These folks will then be required to take more mathematics at the college level, and then teach mathematics to their elementary students, a formidable task for many in this position. When these preservice elementary school teachers graduate and become teachers, they will be expected to effectively teach their students the mathematics fundamentals necessary for success in the rest of their mathematics careers (Ford, 2015). Not only must teachers understand the concepts, they must also understand how the students learn these concepts, and thus how the concepts should be taught (Ford & Strawhecker, 2011).

Yet, many preservice teachers do not believe they will have the ability to teach mathematics adequately (Bursal & Paznokas, 2006). For many teachers, their mathematics anxiety can have negative impacts on their confidence as a teacher. The Bursal and Paznokas study (2006) investigated how preservice elementary teachers' mathematics anxiety levels relate to their confidence to teach elementary mathematics. The results of the study showed a fairly strong, negative correlation ($r = -.638$) between the preservice teachers' mathematics anxiety and their confidence to teach elementary mathematics. Teachers who reported higher levels of mathematics anxiety tended to report lower levels of confidence to teach elementary mathematics (Bursal & Paznokas, 2006).

Preservice Mathematics Anxiety and Teacher Self-Efficacy

In a similar way that mathematics anxiety can negatively impact one's confidence to teach mathematics, it can negatively impact the self-efficacy of elementary teachers. Self-efficacy refers to an individual's belief that he or she is capable of accomplishing certain tasks or succeeding in certain situations (Bandura, 1977). Similarly, teacher efficacy is a two-dimensional construct that refers to one's belief in his or her abilities to teach students effectively, as well as their belief that effective teaching can lead to student learning, regardless of external factors (Enochs et al., 2000). Past research has related teacher self-efficacy to aspects of teaching such as the methods of instruction teachers use and their student achievement (Swars & Daane, 2006). One reason that researchers believe teacher self-efficacy is positively correlated with student achievement is because those teachers with high self-efficacy are more equipped to meet the needs of a wider range of students than those with lower teacher self-efficacy (Ross & Bruce, 2007).

As alluded to in the previous paragraph, low levels of teacher self-efficacy have been linked to high levels of mathematical anxiety. A 2006 study of 28 preservice elementary teachers found a modest, negative correlation ($r = -.440$) between mathematics anxiety and mathematics teacher efficacy (Swars & Daane, 2006). Another study published in 2009 found similar results. In that study, researchers examined mathematics anxiety and mathematics teacher self-efficacy in 156 preservice elementary teachers and found a modest, negative correlation ($r = .475$) between mathematics anxiety and mathematics teacher self-efficacy (Gresham, 2009). More recently, a study published in 2017 further supported these results. While this study consisted of 96 preschool teachers as opposed to elementary preservice teachers in the prior studies, the results were consistent with previous research. The authors of this study found a negative correlation between participants' mathematics anxiety and mathematics teacher self-efficacy, however the r statistic was not reported (Cook, 2017).

Impact of Teachers' Mathematics Anxiety on Students

When these preservice teachers with mathematics anxiety become practicing teachers, their reservations towards mathematics can have a negative impact on their students' ability to learn mathematics. Past research suggests that teaching mathematics successfully is very much dependent on one's attitudes and beliefs towards mathematics (Cornell, 1999). Not only do elementary teachers report high levels of mathematics anxiety, but they are also susceptible to passing this anxiety on to his or her students through daily interactions (Austin et al., 2001; Beilock et al., 2010; Bush, 1989). The teachers' negative feelings towards mathematics and mathematics teaching can have negative effects on student outcomes (Ma, 1999).

For instance, teachers with high levels of mathematics anxiety are more inclined to resort to lecturing as a means of instruction, as opposed to implementing more collaborative, active learning experiences (Gresham, 2018). When these teachers spend the majority of the class time lecturing, they end up emphasizing basic skills instead of leading students to conceptual understandings (Finlayson, 2014). Past research has indicated that implementing a number of different learning experiences such as games, problem-solving activities, and group work and discussion can help to lessen mathematics anxiety in both teachers and students (Lake & Kelly, 2014).

While a teacher with mathematics anxiety may feel more comfortable resorting to lecturing, other research suggests this instructional mode may stimulate their mathematics anxiety. When a teacher is in front of a classroom instructing, the situation feels as though they are under evaluation, which causes the teacher’s anxiety to be heightened (Tooke & Lindstrom, 1998). This is because mathematics anxiety, in most people, is evoked in situations where they must demonstrate their mathematics knowledge, such as teaching a class (Uusimaki & Nason, 2004). When it appears to the student that the teacher doesn’t have adequate mathematics knowledge, it can cause feelings of anxiety to arise in that student (Finlayson, 2014). Studies have also shown that student achievement may be hindered by a mathematically anxious teacher, whether male or female (Beilock et al., 2009).

In addition to experiencing anxious feelings towards mathematics, many elementary school teachers lack a deep understanding of the fundamental mathematics concepts that are taught at the elementary level. In most cases, preservice elementary teachers can become certified without having taken rigorous mathematics courses that cover content beyond what is taught during the elementary years (Epstein & Miller, 2011). For example, a 1988 study indicated that a significant percentage of preservice elementary teachers had misconceptions about multiplying and dividing decimals that were similar to those of 10-12 year-olds, with both groups making similar mistakes on these types of problems (Graeber & Tirosh, 1988). Similar studies of preservice and inservice elementary teachers in the United States found that these teachers had weak conceptual understandings of division, and had trouble connecting division to examples in the real-world (Ma, 1999; Simon, 1993). So, while elementary teachers can follow rule-bound mathematics procedures, many lack the pedagogical content knowledge and mathematical understanding required to explain to students why these procedures work, and why they should select certain procedures over others (Ball, 1990). And while many of these studies examined preservice teachers, it is likely that these teachers' competencies did not improve without intervention. Ultimately, this lack of mathematics understanding and pedagogical content knowledge in elementary school teachers may be an important factor that helps to explain the poor performance of their students (Anderson & Kim, 2003). This study fills a significant gap in the research by comparing the levels of anxiety between preservice and inservice elementary teachers in the same study.

Professional Development for Teachers

While there have been previous research studies aimed at learning how professional development has impacted elementary mathematics teachers, few have specifically examined how professional development impacts a teachers' mathematics anxiety, either by increasing or decreasing anxiety. Instead, past research has investigated topics such as how teachers' instructional strategies have changed after participating in professional development, or how their mathematics content knowledge changed after the professional development. Past research on professional development across various content areas has helped to develop a framework that suggests that effective professional development models should draw from six key elements: content focus, active learning, coherence, duration, form, and collective participation (Darling-Hammond & Wei, 2009; Odden, 2011). In order for teacher professional development to be effective, their training should be closely related to the tasks the teachers will undertake in practice (Ball & Cohen, 1999). Additionally, a positive effect on teaching practices has been shown when teachers participated in professional development that emphasized student learning and improving teachers' pedagogical skills (Darling-Hammond & Richardson, 2009). There is also research to suggest that a teacher's improved skill in handling of active learning will help them to better provide feedback to students, review student work, and lead classroom discussions (Van den Bergh et al., 2014). Professional development should also align with state education standards and assessment (Desimone, 2009).

A research study conducted in 2009 sought to improve how elementary mathematics was taught in one district by providing the teachers with professional development designed specifically to deepen teachers' mathematics content knowledge and lower teachers' mathematics anxiety (Good et al., 2009). And while this study was confined to a single school district, the researchers found that prior to the professional development, teachers had much lower levels of mathematics anxiety than anticipated, and much higher mathematics teacher efficacy than expected. The researchers noted, however, that this could be because teachers volunteered to take part in the study and professional development, so those with high mathematics anxiety may have felt less comfortable in a study where their mathematics competency and anxiety would be measured.

Duration suggests that professional development activities are most effective when they have a longer duration or are spread over a long period of time, rather than the traditional one-shot workshop approach. Unfortunately, considerable improvement in individual learning is neither quick nor linear (Campbell & Malkus, 2011). A study done by Soliday (2015) investigated the impact of an intensive, ongoing professional development model on K-8 teachers' mathematics content knowledge, in addition to their pedagogical knowledge. These teachers participated in a ten-week professional development program, meeting once a week for three hours. This ongoing effort lead to an increase in teachers' pedagogical knowledge, as indicated by pre-tests and post-tests (Soliday, 2015). Additionally, other studies have also shown that student achievement is positively related to the number of hours teachers spend on professional development activities (Darling-Hammond et al., 2009; Yoon et al., 2007).

The Training and Role of Instructional Coaches

Maine is not the first state to identify the need to train teachers to become mathematics coaches. Campbell and Malkus (2011) reported on a study involving five school districts in Virginia. The state of Virginia defines mathematics specialists (coaches) as "teacher leaders in elementary and middle schools who work primarily with classroom teachers to strengthen their mathematics content knowledge and their pedagogical practices (Ellington et al., 2012). Within the five districts, 24 mathematics coaches were assigned to various elementary schools. The coaches came from varying backgrounds, with about half of them holding master's degrees. However, each of the coaches had some degree of prior experience teaching mathematics at either the elementary or middle-school level. Before becoming mathematics coaches, these teachers took five courses designed by college mathematics and mathematics education faculty, district mathematics coordinators, and experienced classroom teachers. Some of the courses were taught with the goal of increasing the coaches' mathematics content knowledge, whereas other courses were taught with an aim to increase pedagogical knowledge.

This stands out as a significant difference in preparation of the Virginia mathematics coaches compared to mathematics coaches from the MMCP. The Virginia coaches took five courses dense with mathematics content knowledge and pedagogical knowledge, taught by both a mathematician and a mathematics educator. The participants in the MMCP, on the other hand, took only one course involving mathematics content knowledge and pedagogical content knowledge. Most of the program focused on designing, implementing, and refining of the math coaching practice. A study published in 2011 found a positive relationship between instructional coaches' educational background in mathematics and their mathematics content knowledge and pedagogical content knowledge (Mccrary, 2011). So, one could infer that the more content courses a coach completes, that better equipped they will be support the teachers they coach.

Beyond prospective mathematics coaches taking courses that strengthen their mathematics content knowledge and pedagogical content knowledge, it is important for the coaches' training to reflect aspects of the actual job of a mathematics coach. One study found that the steps teachers took in learning to become successful mathematics coaches are similar to how they will lead teachers as the mathematics coach (Green & Kent, 2016). That is, prospective coaches learned through a cyclical collaboration with a more knowledgeable other, who observed and provided feedback to support reflection, just as coaches do with the teachers they support. This learning strategy, followed by reflective feedback, is consistent with a social constructivist framework.

There is more to becoming a successful mathematics coach than just possessing strong content knowledge in mathematics. A mathematics coach, specialist, or teacher leader will have multiple responsibilities in his or her role. Teachers have noted that an effective mathematics coach should be a resource, a lead teacher, a mentor, and an aid to help other teachers to improve student achievement, provide analysis of test scores, and evaluate colleagues' teaching (Dobbins & Marilyn Simon, 2010). To go further, coaches should be a supporter of the teachers, a supporter of the students, a learner, and a supporter of the entire school (Chval, 2010). As a coach, being a learner is crucial because when leaders are willing to change their ways and adapt to new strategies and approaches, teachers will be more willing to change and adapt as well

(Dobbins & Marilyn Simon, 2010). On top of all the responsibilities of the mathematics coach, he or she must be a qualified leader (Fennell et al., 2013). For this reason, mathematics coaches should not be hired strictly because they are exceptional mathematics teachers. Often times, teachers who are hired as coaches based only on their ability as a teacher receive somewhat of a "wake-up call", as they are underprepared for the constant, diverse, and challenging leadership responsibilities they undertake as a coach (Fennell et al., 2013).

Additionally, a successful coach should be able to immerse themselves into the culture of the school. Several factors have been identified as having an effect on a coach's ability to be accepted in teachers' classrooms, including: the coach's interpersonal skills, staff views of the coach, staff relationships and culture of the school, the coach's ability to adapt their identity to fit the culture of the school, teachers' resistance or hesitance to be observed by peers, and the importance of trust and confidentiality (Hartman, 2013). One way to gain acceptance into the school is through collaboration with the principal. The support of the principal has been found to be an important factor in terms of increasing teachers' acceptance of the instructional coach and maximizing the mathematics coach's impact (Dempsey, 2007; Hartman, 2013; Mangin, 2007). Prior research suggests that the impact of the mathematics coach is greatest when working closely with the principal (Grant & Davenport, 2009). For the mathematics coach to be able to properly implement their strategies, the principal must share similar goals with the mathematics coach. Grant and Davenport (2009) suggest principals meet regularly with coaches to maintain a clear vision of the goals and priorities for the school year. Between the principal and coach, a set of norms for teacher collaboration and participation in professional development should be established. Regular meetings between the principal and coach can help both sides agree on a clear job description that can be made explicitly clear to teachers.

The amount of time teachers spent with the coaches was mentioned earlier as a factor that weighed heavily in the success of the coach in prior studies. The amount of time a teacher spends with the coach will affect how comfortable the two are with one another. One study indicated that when the coach and teacher met infrequently, the teacher didn't feel comfortable enough to have an open conversation about her experiences and needs in the classroom (Gellert & Gonzalez, 2011). Other teachers in this study reported that the infrequent meetings were rushed and didn't allow for an in-depth look into their teaching. When coaches are able to spend more time with teachers, they can develop a productive relationship that can lead to instructional change for the teacher (Drust, 2015). Data taken from schools in South Carolina where coaches logged their daily activities found that instructional coaches provided the school the equivalent of eight professional development days over the course of the year (Dempsey, 2007).

Being observed and observed by a mathematics coach can be a potential cause of concern and anxiety for teachers. This is another reason why it is crucial for the teacher-coach relationship to be an open, comfortable one. Positive change for teachers happens when a coach allows them to practice new material in a safe environment (Barkley, 2005). With a sustained effort, however, teachers can learn that the feedback from coaches is nonevaluative, and nonjudgmental, and will help them better understand students, as well as improve their instructional abilities (Dobbins & Marilyn Simon, 2010).

Additionally, past research has shown that coaches with a strong knowledge of their district's curriculum were better equipped to understand the interrelations of K-5 education, and thus provide better support for the teachers they helped (Green & Kent, 2016). Some research has shown that issues arise when teachers don't believe their new teaching strategies align with state standards. For example, teachers in New York reported that it is challenging to implement innovative, non-traditional teaching strategies when much of their time was spent preparing students for the state's Regents exams using traditional test preparation guides (Gellert & Gonzalez, 2011).

Impact of Mathematics Coaching on Teachers

Planning

One way in which mathematics coaches can provide support for teachers is by assisting with lesson planning. Due to the busy schedules of teachers, they often have limited time to plan with other teachers, or to attend outside professional development sessions (Taylor, 2017). Lesson planning with teachers also allows for the coach to get a sense of where teachers are at in terms of their beliefs and their content knowledge (Zuspan, 2013). Lessons are more easily developed when teams of teachers are working together, discussing strategies and providing stimulus to one another to come up with new ideas (Dobbins & Marilyn Simon, 2010). As time goes on, teachers see how planning collaboratively can positively impact both their instruction and student learning (Zuspan, 2013). This allows for teachers to try out instructional approaches while receiving immediate feedback from the coach or specialist (Jackson et al., 2015).

Instruction

As mentioned earlier, a key component of effective professional development is duration. One advantage coaching can have over other professional development efforts is that coaching can be sustained over a long period of time. Onsite and sustained collaboration with coaches is crucial in developing teacher efficacy (Taylor, 2017). One study examining over 80 schools in California showed that when teachers attended a one-time professional development session, only 10% implemented their newly acquired skills in the classroom. Alternatively, when schools added coaching to develop faculty, about 95% of the teachers implemented newly learned skills

(Cornett & Knight, 2008). Over time, teachers will come to better understand new approaches to teaching and learning, as well has how to implement these approaches (Dobbins & Marilyn Simon, 2010). Depending on the model, coaches can also partner with the teachers on lessons. This allows for the coach to model ways to align instruction to standards when a teacher may be struggling (Taylor, 2017). Teachers have also reported an increased confidence in teaching mathematics after working with a mathematics coach. By learning how to implement effective instructional strategies and gaining experience with new strategies and mathematics ideas, teachers felt more confident after collaborating with a mathematics coach.

Drust (2015) also completed a study with the goal of answering research questions similar to the proposed study. That qualitative study was aimed at evaluating the effectiveness of a mathematics coaching program designed similarly to the MMCP. Drust (2015) developed her own questionnaire instead of using a pre-developed assessment instrument. Elementary school teachers, who had participated in professional development that included collaboration with mathematics coaches, reported on the efficacy of the coaching program by responding to the open-ended questions on the questionnaire. The questionnaire included questions such as, "How did the coaching professional development experience influence your instruction practice?", "What aspects of the coaching professional development were positive?", "What would you change about the coaching professional development?", and "How did the coaching professional development influence your students' mathematics achievement?" In addition to the questionnaire, some participants also agreed to participate in face-to-face interviews. The face-to-face interviews provided participants with a chance to better articulate how their attitudes and approaches to mathematics instruction had changed as a result of the professional development and coaching. As a result of working with a mathematics coach, teachers felt they were better able to meet the various and unique needs of students, and felt that the implementation of a mathematics coach was an "invaluable asset" in improving and reforming their instructional approaches (Drust, 2015).

A similar study was conducted in Maine to investigate the effectiveness of a professional development program that trains mathematics coaches to coach special education and general education teachers at their schools (Lech et al., 2018; Mason et al., 2017; Mason & Tu, 2015). The program targets teachers in grades three through six from schools with low mathematics achievement and aims to improve the teachers' conceptual understanding of fundamental mathematics topics to be able to better support student understanding. The mathematics coaches formally observe teachers and provide verbal and written feedback three times per year, but also provide numerous informal observations and feedback throughout the year. To date, 101 teachers and 12 coaches have participated in the training. The majority of teachers reported that the coaching was helpful in equipping them to implement NCTM instructional practices. Teachers noted that they especially benefitted from the feedback provided by the coaches, as well as observing the coach modeling effective instruction, and would like even more frequent collaboration with the mathematics coach (Lech et al., 2018; Mason et al., 2017).

A pre- and post-test given to the teachers during the summer indicated that the group showed an increase in mathematical content knowledge. Additionally, both the coaches and teachers cited specific examples of ways the teachers' instructional abilities improved because of the professional development. Analysis of classroom observations also indicated that teachers' instructional abilities improved more substantially in their second year of participation. Furthermore, evaluators of the program concluded that the training, in addition to the coaching, had positive impacts for improving teachers' content knowledge, pedagogical knowledge and skill in implementing key instructional strategies outlined in the NCTM's *Principles to Action* (Lech et al., 2018; Mason et al., 2017). A separate examination of students' scores on the state mathematics test for the first cohort indicated that there was more of a reduction in the decline in students' test scores rather than an overall gain, and higher gains for younger students in grade four than upper elementary grades. It should be noted that most of the students were special education students who typically perform below grade level and thus face significant challenges in performing well on grade level assessments. The evaluators conjectured that more intensive teacher training and coaching may be needed to see a significant positive effect on student mathematics test performance (Mason, Tu, & Liang, 2017).

Impact of Mathematics Coaching on Students

Much of the research done on mathematics coaching has examined how coaching directly impacts the teachers. Implementing a large-scale study to determine the effect of mathematics coaches on students is expensive. To determine the effectiveness of the coaches in the Campbell and Malkus (2011) study, each coach was closely monitored as data were collected over a three-year study. The overarching question motivating the research was as follows: Does the placement of an elementary mathematics coach affect student achievement across a school? The student-level data consisted of student scores on the mathematics section of the Standards of Learning Assessment (SOL), taken annually by all students in grades 3 through 8 in Virginia. The dependent variable for this data set was overall SOL mathematics scale score for three years, for each grade level. The researchers found that, over a three-year period, students in grades 3-5 in schools with an elementary mathematics coach scored statistically significantly higher on their high-stakes standardized mathematics achievement test than students in schools without a mathematics coach (Campbell & Malkus, 2011). This impact was the strongest in grades four and five, likely due to more challenging content being introduced in the upper levels of elementary school. The study did show, however, that mathematics coach placement did not make a significant impact on student achievement in the first year of implementation, further alluding to the idea that professional development must consist of sustained, prolonged efforts to be effective. In another study, teachers reported that they felt as though students benefitted "considerably" from participating in active learning and hands-on lessons provided by the mathematics coach (Drust, 2015).

While this study investigated the impact of mathematics coaches on students, it did not advance the literature on the impact of mathematics coaches on teachers' attitudes towards mathematics or teachers' feelings of self-efficacy, confidence or anxiety with mathematics. Additionally, the study did not address issues such as how coaching practices influenced the instructional practices in these schools, how coaches changed their own focus, organization, priorities, coaching knowledge, and skills, how coaches interacted with teachers, how the coaches' beliefs and philosophies conflicted with those of the teachers, and how administrators and teachers viewed the role of the coach. Over the course of the three-year study, 1,593 teachers in kindergarten through fifth grade agreed to participate in the study. It should be noted that each of the 24 elementary mathematics coaches who participated in the study were paid a $2,500 annual stipend.

In 2003, schools in South Carolina adopted a model where participating schools would host one coach per school to improve one content area. After three years, schools saw statistically significant gains on third through fifth grade students' scores on the Palmetto Academic Achievement Test. A similar study by Dobbins and Simon (2010) also revealed a positive relationship between coaching and student achievement, as they measured a significant increase in mathematics achievement amongst students in the last quarter of the year at the school in question.

Instruments for Assessing Anxiety Towards Mathematics and Mathematics Teaching

Various instruments have been developed for assessing mathematics anxiety and attitudes towards mathematics in general. It is critical to the nature of the study to implement tools that have been validated through published research.

It is important to note that only scores, and not the test themselves, can be either reliable or unreliable. Gronlund and Linn (Gronlund & Linn, 1990) stated that "reliability refers to the results obtained with an evaluation instrument and not to the instrument itself. Thus, it is more appropriate to speak of the reliability of 'test scores' or the 'measurement' than of the 'test' or the 'instrument'". The literature suggests that the reliability of individual item scores on a survey for measuring particular constructs is typically determined using Cronbach's alpha reliability coefficient (Gliem & Gliem, 2003). Cronbach's alpha is a comparison of the correlation between the score of each scale item and the total score (out of the entire scale) for each observation and the variance of the individual item scores (Goforth, 2015). Experts in the field recommend a minimum alpha coefficient between 0.65 and 0.8 for an item's scores to be deemed a sufficiently reliable measure (Goforth, 2015).

Validity, another important consideration for a study, refers to the conclusions one makes about cause and effect relationships as a result of the measurement (Trochim, 2006). Within the context of our study, validity refers to whether any improvements we observe in the elementary teachers' attitudes towards mathematics or mathematics teacher efficacy are actually a result of the coaching intervention.

Previous studies that have investigated mathematics anxiety in elementary teachers have used the Mathematics Anxiety Rating Scale (MARS) to measure the levels of mathematics anxiety in teachers (Bursal & Paznokas, 2006; Gresham, 2017; Swars & Daane, 2006). The MARS, developed by Richardson and Suinn (1972), is a self-reported inventory with Likert-style questions developed to assess anxiety towards mathematics. The MARS has been used in previous studies to measure the mathematics anxiety levels of inservice elementary teachers (Gresham, 2018). The original MARS, however, has 98-items, making it an unrealistic option for busy preservice and inservice elementary teachers. To address the issue of length, researchers have opted for adapted versions of the MARS. One such version of the Revised Mathematics Anxiety Scale (R-MARS), developed by Alexander and Martray (1989), has only 25 items. One study tested the instrument's construct validity by subjecting it to a confirmatory factor analysis. The analysis indicated that five items should be dropped from the original R-MARS, reducing the total number of items to 20. The 20-item version of the R-MARS was validated by the same study, indicating that it is a reliable research tool (Ballu & Zelhart, 2007). With the R-MARS being only 20 items, it becomes a feasible instrument for assessing mathematics anxiety in elementary teachers.

Liu (2008) developed the 15-item Anxiety Towards Teaching Mathematics Questionnaire (ATTMQ), with a five-point (1-5) scales for responses. The questions on the ATTMQ are categorized five ways: anxiety due to the feeling that mathematics is more difficult than other school subjects; anxiety about how others might perceive one's teaching of mathematics; anxiety due to one's content knowledge of mathematics; anxiety due to teaching mathematics in general; and anxiety due to teaching in general (Liu, 2008). This construct is advantageous as it allows for researchers to better understand the nature of one's anxiety towards teaching and doesn't categorize a teacher as simply being mathematically anxious. In the study Liu published regarding the use of the ATTMQ amongst preservice elementary teachers, Liu reported a reliability coefficient of 0.85 and 0.88 for pretest and posttest items respectively, which indicates a high level of internal reliability (2008). In terms of mathematics anxiety, Liu wanted to investigate how the use of online discussions influenced anxiety towards teaching mathematics amongst preservice elementary teachers taking a mathematics methods course. Results of the pre and post tests indicated that preservice teachers had decreased levels of anxiety towards teaching mathematics when they participated in online discussions regarding the following three constructs: anxiety caused by the conception that mathematics is more difficult, anxiety towards other people's perception of one's teaching of mathematics, and anxiety towards teaching in general. For the other two constructs (anxiety towards one's content knowledge of mathematics and anxiety towards teaching mathematics in general), the differences between the pre-test and post-test were not significant.

Other instruments to assess one's anxiety towards mathematics or towards teaching mathematics have been developed, but ultimately have limitations that may make them inappropriate for this study. The Mathematics Teaching Anxiety Survey (MATAS) was developed by Peker in (2006). Similar to the MARS, the MATAS uses items on a five-point Likert scale, and categorizes questions in a fashion similar to the constructs in the ATTMS. The challenge with the MATAS is that the original version was written in Turkish and would require translation to be used in an English-speaking setting. Translation of the MATAS could be limiting in terms of both time and money, as well as potentially altering the intent of the items.

The Attitudes Towards Mathematics Inventory (ATMI) (Tapia & Marsh II, 2004) was developed as an alternative to the extensive, and potentially unreliable Fennema-Sherman

Mathematics Attitudes Scales, which consisted of 108 items. However, at 49 items, the ATMI still requires a fair amount of time and focus, potentially dissuading participants from responding honestly and thoroughly. According to literature, the ATMI has only been used for students. To use it with preservice and inservice teachers, certain questions would need to be altered, which could be potentially damaging to the reliability of the results.

Gaps in the Research

While some research has been conducted to better understand the elements of successful coaching and mathematics coaching specifically, and the impacts of coaching on students' test scores, there is relatively little research on how mathematics coaches improve elementary teachers' attitudes towards mathematics and their self-efficacy beliefs. Anxiety and self-efficacy are the major themes of this study. Further, most of the research on mathematics anxiety and self-efficacy for teachers was done with preservice teachers. One goal of this research project will be to advance the literature on mathematical anxiety and math teacher efficacy in inservice teachers, and how those levels compare to preservice elementary teachers.

Beyond examining the levels of mathematics anxiety amongst elementary teachers, this study also aims to better understand how teachers' attitudes towards mathematics are impacted from collaboration with a mathematics coach. Furthermore, this study may provide insight on how teachers' confidence towards teaching mathematics and self-efficacy for teaching mathematics are impacted by working with a mathematics coach.

Theoretical Framework

<u>Social Constructivist Perspective</u>

This study will draw on a social constructivist perspective. Social constructivism refers to a theory of learning where students actively construct their knowledge, and therefore information is not simply passed from the teacher to the learner, but rather built from the experiences of the learner and their interactions with a social environment (Glasersfeld, 1995; Schcolnik & Abarbanel, 2006). Social constructivism encourages learning through discussion, reflection, and consistent feedback. In *Exploring Social Constructivism,* Paul Adams provides a list of guidelines to consider while teaching from a social constructivism perspective: (1) focus on learning not performance, (2) view learners as active co-constructors of meaning and knowledge, (3) establish a teacher-pupil relationship built upon the idea of guidance not instruction, (4) seek to engage learners in tasks seen as ends in themselves and consequently having implicit worth, and (5) promote assessment as an active process of uncovering and acknowledging shared understanding.

The components of a social constructivist perspective are especially pertinent to this study because there are two learners in this situation, the teacher receiving professional development, and the coach, specialist, or teacher leader. The coach is important in this scenario because he or she allows for the teacher to continue their own learning, and thus become a more effective teacher. Through the social interactions of the mathematics coach and the practicing teacher, the teacher will be able to build upon his or her prior knowledge of addressing student needs to develop an improved approach in their instruction. One question that will be investigated is whether coaching improves teachers' mathematics anxiety and confidence to teach mathematics so that they can support the learning needs of their students in mathematics.

Within the social constructivist framework, this study will be approached from a Vygotskian perspective, which emphasizes the social nature of learning. In this perspective, learning takes place in the presence of a more experienced or more knowledgeable other, such as an instructional coach. Vygotsky believed that learning takes place through social interactions, not just with other humans, but with non-humans, as well as signs and tools (Abtahi et al., 2017) (Abtahi et al., 2017). Rogoff (1990), also noted that these tools are "socio-historically developed" and should "mediate intellectual activity". In this case, the more knowledgeable other is the mathematics coach, specialist, or leader. And, from this perspective, the tools are of a similar importance of the more knowledgeable other, and therefore must be historically and culturally relevant.

Instructional Coaching

Kurz et al. (2017) developed a multidisciplinary framework for instructional coaching. Kurz determined that the literature presented a variety of frameworks for instructional coaching aimed at improving the performance of professionals, many of which were under-researched. To provide a solution, Kurz et al. reviewed the literature on coaching in education, sports, and business, and created a framework for instructional coaching in education that blends positive aspects of the various frameworks. The research team first identified coaching actions, and determined which fields (education, sports, business) utilized those coaching actions. Some examples of coaching actions they identified were: questioning, assessing, observing, contextualizing, supporting, evaluating, goal setting, etc. Additionally, the team identified coaching outcomes that occur across the three fields. Examples of these outcomes include: performance enhancement, environmental improvement, community development, promotion of autonomy, professional satisfaction, enhanced cognition, etc. The team found where these actions and outcomes overlapped across the three fields to identify the dimensions of the framework. The team decided on the following actions for the multidisciplinary framework: a) questioning: providing questions to guide thinking and self-reflection; b) assessing: synthesizing information and data to identify coaching needs for teachers and students; c) setting goals:

prioritizing and operationalizing areas for improvement; d) planning: providing support in the implementation of plans of action; e) demonstrating: providing effective modeling and practice; f) critiquing: providing on-going performance feedback to encourage and sustain effort and reach desired outcomes; g) evaluating: considering implementation quality or performance relative to a desired benchmark; and h) adjusting: making changes and refining implementation and practices (Kurz et al., 2017).

Additionally, researchers identified three foci within the scope of coaching: a) skills: coaching targets discrete skills; b) process: coaching targets a process or progression of activities; or c) development: coaching targets the application of skills and processes to achieve growth toward personal or profession goals (Kurz et al., 2017). Lastly, the researchers determined outcomes that are prominent across disciplines and apply to education: a) performance enhancement: improvements in specific teacher practices or student academic or behavioral outcomes; b) environmental improvements: targets include improvements in physical learning environments; c) promotion of autonomy: establishing independence in the implementation of practices; d) enhancement of cognition: refinement in framing of thinking and decision making; or e) community development: improvement in community's responsiveness to school-wide, teacher(s) and student(s) needs (Kurz et al., 2017). This framework informed data analysis in the present study for inservice teachers' written comments on two open-ended survey items asking about the coaching activities they experienced and perceived benefits of that coaching.

Causal Theory

The goal of this study was to better understand how elementary mathematics teachers' attitudes and feelings towards mathematics and teaching mathematics are impacted by working with a mathematics coach. I hypothesized that many elementary teachers develop a negative relationship towards mathematics because of negative experiences involving mathematics early in his or her life. These negative experiences may cause students to experience mathematical anxiety, as well as lower levels of self-efficacy and self-confidence in mathematics. Over time, this can cause students to become disinterested in mathematics, and perhaps attempt to avoid mathematics all together. Some of these students with negative feelings towards mathematics go on to major in elementary education, perhaps knowing that rigorous mathematics courses are not a requirement for the program. For many students, the mathematics instruction they receive as undergraduates may not be effective in lowering their levels of mathematical anxiety or increasing their self-efficacy in mathematics. The result is that many preservice elementary teachers enter the field with an insufficient understanding of fundamental mathematics concepts. I hypothesized that this lack of content knowledge, as well as potentially high levels of mathematical anxiety and low levels of mathematics teacher efficacy, will have negative impacts on the quality of their mathematical instruction, and their ability to meet the needs of all their students. As a result, the outcomes of some students may be negatively impacted.

With the intervention of a mathematics coach, however, I believe that the confidence level to teach mathematics in teachers can be improved. By working with a mathematics coach, teachers will become more comfortable and more confident in teaching certain topics. Further, they may develop a deeper understanding of certain topics in mathematics, and thus be able to provide more effective feedback and support to their students. Finally, I believe that working with a mathematics coach may decrease levels of mathematical anxiety for some teachers, as well as increase their efficacy as mathematics teachers. If elementary mathematics teachers develop improved instructional abilities, students may leave the elementary grades with stronger conceptual understandings of the mathematics topics covered in the elementary grades than students in prior years and perhaps more positive views of mathematics as well.

This study will specifically focus on the impact that working with a mathematics coach has on elementary teachers' mathematics anxiety and confidence to teach mathematics, in addition to comparing the levels of anxiety and self-efficacy between inservice and preservice elementary teachers. I hypothesized that the levels of mathematics anxiety would be higher among preservice teachers than inservice teachers. Similarly, I anticipated the mathematics teacher efficacy levels would be higher amongst inservice teachers than preservice teachers. Finally, I hypothesized that the teachers who work with coaches would report positive impacts.

Chapter 3: METHODOLOGY

Quantitative methods were used to explore preservice and inservice elementary school teachers' attitudes towards mathematics and the impact of mathematics coaches on inservice elementary teachers. Chapter 3 presents the research design and describes the methods employed to answer the research questions. The purpose of the study is restated, followed by a restatement of the research questions and an explanation of the study design. The chapter will end with a description of how data were collected for this study, followed by an explanation of the data analyses techniques used.

Purpose of the Study

The purpose of this study was to better understand the nature of inservice and preservice elementary teachers' feelings about mathematics and their perceptions of self-efficacy in teaching mathematics. Additionally, the study aimed to better understand how working with a mathematics coach affects inservice elementary teachers' feelings about mathematics and their perceptions of self-efficacy in teaching mathematics. There is a fair amount of existing research already on preservice elementary teachers' feelings towards mathematics and their self-efficacy, but little research has been done to study those factors in inservice elementary teachers, or to compare the two groups of teachers to understand how teachers' self-efficacy changes over time as they gain teaching experience. There has also been little research investigating how elementary mathematics coaches can have a positive impact on the self-efficacy of inservice elementary school teachers. This study aims to address these gaps in the literature.

With more school districts beginning to hire mathematics coaches, there is a need to better understand the impact coaches can have on inservice elementary mathematics teachers. Hearing from the teachers can provide important insights to coaches and school principals about what teachers feel is most helpful in the coaching experience and what is less helpful. This study provides limited evidence for more districts to hire instructional mathematics coaches. By hiring more mathematics coaches, districts could address the issue of elementary school teachers lacking confidence in teaching mathematics due to their negative feeling towards the subject.

Research Questions and Design

This study was guided by the following questions:

1. How do the reported levels of mathematics anxiety and mathematics teacher efficacy compare between inservice elementary teachers and preservice elementary teachers?
2. What was the reported impact of mathematics coaches on inservice elementary teachers' anxiety towards mathematics and confidence to teach mathematics?
3. What aspects of working with a mathematics coach do elementary inservice teachers report to be the most beneficial?
4. What is the relationship between mathematics anxiety and mathematics teacher efficacy for inservice elementary teachers and preservice elementary teachers?

Population

The inservice population in this study included elementary teachers from districts across a rural state in northeastern US. The preservice population consisted of preservice elementary teachers enrolled in one of two mathematics methods courses at a small, land-grant university in the same northeastern state. Those seeking an elementary education endorsement are required to pass both mathematics methods courses in this state.

Sample

A total of 3,341 inservice teachers were invited to participate in the survey via an email that included a link to the survey. Of those teachers, 225 submitted the survey, yielding a 6.7% return rate. After incomplete responses were removed from the inservice data, 174 inservice participants remained in the sample. The preservice sample accessed the survey during class via a link or QR code. A total of 70 preservice participants were provided with either the link or QR code. After incomplete responses were removed from the preservice data, 51 preservice participants remained in the sample, yielding a 73% return rate.

Participants

Of 174 inservice teachers who completed the survey, 159 were female (91.4%) and 15 were male (8.6%). In terms of educational attainment, 44.3% of the sample's highest degree was a bachelor's, while 48.9% of the sample held a master's degree, 6.3% held an education specialist certificate, and one (0.6%) participant held a doctorate . Most of the inservice teachers were veteran educators: 12.1% of the sample had between zero and two years of teaching experience, 17.2% had three to five years, 15.5% had six to ten years, 24.7% had between 11 and 20 years, and 30.5% had greater than 20 years of teaching experience. Just over a third (35.1%) of the sample indicated they currently worked with a mathematics coach, while the majority (64.9%) did not currently work with a mathematics coach. Table 3.1 displays the demographics for the inservice elementary teachers.

Table 3.1
Inservice Elementary Teacher Demographics Data (n=174).

Teacher Demographics	%
Sex	
Female	91.4%
Male	8.6%
Highest Degree Earned	
Bachelor's	44.3%
Master's	48.9%
Education Specialist	6.3%
Doctoral	0.6%
Years of Teaching Experience	
0-2 years	12.1%
3-5 years	17.2%
6-10 years	15.5%
11-20 years	24.7%
20+ years	30.5%
Works with Mathematics Coach	
Yes	
No	35.1%
	64.9%

After incomplete responses were removed from the preservice data, 51 preservice participants remained in the sample. Of these 51, 48 were female (94.1%) and 3 (5.9%) were male. The majority (80%) of the preservice sample were elementary education majors, while eight (16%) participants were scattered across majors such as childhood and family relations, early childhood education, art education, secondary education, and psychology. Two participants (4%) indicated being undecided. Table 3.2 displays the graphics for the preservice elementary teachers.

Table 3.2
Preservice Teacher Demographics Data (n=51).

Preservice Teacher Demographics	%
Sex	
Female	94.1%
Male	5.9%
Major	
Elementary Education	80%
Child Development and Family Relations	3.9%
Early Childhood Education	3.9%

Table 3.2 Continued

Art Education	3.9%
Secondary Education	1.9%
Psychology	1.9%
Undecided	3.9%

Data Collection

An online survey distributed via Qualtrics was used to collect data on inservice and preservice elementary teachers' attitudes towards mathematics, feelings of efficacy in mathematics, and inservice elementary teachers' perceptions of their experiences working with a mathematics coach. Using Qualtrics allowed the researcher to collect completely anonymized responses, and to easily send out reminder emails. Both the inservice and preservice sample responded to the Revised Mathematics Anxiety Rating Scale (R-MARS) (Alexander & Martray, 1989) and Mathematics Teaching Efficacy Beliefs Instrument (MTEBI) (Enochs et al., 2000). Inservice teachers were given three weeks to complete the survey, while preservice teachers completed the survey during their class time.

Instruments

Two instruments were used to collect data in this study. The R-MARS was used to collect data on elementary teachers' anxiety towards mathematics, while the MTEBI was used to collect data on elementary teachers' beliefs about mathematics teaching efficacy. The R-MARS and the MTEBI were chosen over similar instruments due to their shorter length, and frequent use in similar studies (Bursal & Paznokas, 2006; Gresham, 2018; Gresham, 2009; Swars & Daane, 2006). Higher scores on the R-MARS indicate higher levels of mathematical anxiety, and higher scores on the MTEBI indicate higher levels of mathematics teacher efficacy.

Revised Mathematics Anxiety Rating Scale

The R-MARS originally consisted of 25 Likert-style items. However, an exploratory factor analysis done by Ballu and Zelhart (2007) revealed that five items would need to be dropped to ensure validity of the instrument. Thus, the R-MARS used for this study consisted of 20 items. Each item on the R-MARS described an everyday or classroom situation in which mathematics anxiety may arise. Respondents indicated his or her level of anxiety for each situation on a Likert scale ranging from 1 (no anxiety) to 5 (high anxiety).

However, some items were specific to the classroom, and were originally written from the student's perspective. These items included scenarios such as "thinking about an upcoming math test one week before", "taking a quiz in a math course", and "receiving your final math grade in the mail." To make this portion of the survey appropriate for the inservice sample, the survey asked participants to "think about your most recent experience in a math class and indicate the level of anxiety you felt when you engaged in these different aspects of doing mathematics."

Other classroom scenarios on the preservice survey written from the perspective of the student were rewritten to reflect a teacher's perspective for the inservice survey. For example, items such as "being given a set of multiplication problems to solve" was we rewritten to "demonstrating to my students how to solve a multiplication problem on the board," and "signing up for a math course" was rewritten to "signing up for math-focused professional development session." The total number of items on the R-MARS remained the same for both the preservice and inservice samples.

Mathematics Teaching Efficacy Beliefs Instrument

The original MTEBI is comprised of two subscales, the Personal Mathematics Teaching Efficacy (PMTE) subscale, and the Mathematics Teaching Outcome Expectancy (MTOE) subscale. The PMTE has 13 items, while the MTOE has 8, giving the MTEBI a total of 21 items. The PMTE subscale included items such as "I know how to teach mathematics concepts effectively" and "I understand mathematics concepts well enough to be effective in teaching elementary mathematics". The MTOE subscale included items such as "the inadequacy of a student's mathematics background can be overcome by good teaching" and "when a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher." Each item on the MTEBI is rated on a five-point Likert scale: 5- strongly agree, 4- somewhat agree, 3- neither agree nor disagree, 2- somewhat disagree, 1- strongly disagree. Additionally, eight items on the PMTE were negatively worded, and were reversed scored. Negatively worded items included, "given a choice, I would not invite the principal to evaluate my mathematics teaching", "I do not know what to do to turn students on to mathematics", and "I wonder if I have the necessary skills to teach mathematics", amongst others.

Items on the original MTEBI were written from the perspective of inservice teachers. Therefore, some items were slightly reworded for the preservice teachers to reflect their anticipated future teaching. For example, the item "I am typically able to answer students' questions" on the inservice survey was reworded to "I will typically be able to answer students' questions" for the preservice survey. Another item on the inservice survey, "I find it difficult to use manipulatives to explain to students why mathematics works" was reworded to "I will find it difficult to use manipulatives to explain to students why mathematics works" for the preservice survey.

In an attempt to measure the effectiveness of the mathematics coaches, the inservice survey also included two Likert-style questions about teachers' experiences working with a mathematics coach. These questions asked "using the scale below, please indicate the extent to which you believe working with a math coach impacted your anxiety towards mathematics" and "using the scale below, please indicate the extent to which you believe working with a math coach impacted your confidence to teach mathematics." Both questions had response options ranging from "1- Large Negative Impact" to "5- Large Positive Impact". This portion of the survey also included a free response item that asked teachers to list other ways in which they interacted with a coach, as well as a free response question that stated, "please indicate which aspect of working with a math coach is most beneficial to your teaching". Open-ended questions allowed for teachers to go into detail in describing their experiences working with the mathematics coach. Teachers were able to explain what he or she thought were the positive and negative aspects of their experience with the mathematics coach. Only teachers who indicated they currently worked with a mathematics coach were able to respond to this part of the survey. This portion of the survey also included five fixed-choice items asking about the types of interactions teachers had with the coaches, including whether or teachers were required to work with coaches, how many years teachers had been working with a coach, how frequently they worked with a coach, and which activities they engaged in with a coach.

The inservice survey also had four items to collect demographic data about inservice teachers, including grade levels in which they taught, years of teaching experience, highest degree held, and gender. For the preservice survey, three items were used to collect demographic data, including college major, year of post-secondary education, and gender.

Procedure

Permission to conduct this study was granted by the Institutional Review Board for the Protection of Human Subjects at my university. Once I received permission, I began creating a contact list of inservice elementary teachers with the contact search page on the state's educational agency's website. This site allowed me to filter my searches by district, and to select teachers who were listed as teaching kindergarten, first, second, third, fourth, or fifth grade.

The R-MARS and MTEBI were entered into the Qualtrics survey, as well as the demographic questions. Additionally, the consent form was included in the preamble of the survey, which described what participants would be asked to do with on the surveys, risks and benefits of participation in the study, a confidentiality statement, and contact information for myself.

The first round of data collection involved emails sent to 555 addresses in early April of 2019. The email included an introduction and a brief overview of the survey. Within the email was a link to the survey. Additionally, weekly reminders were sent to those who had not yet participated in the study over the three-week period that the survey was live.

In mid-April, I collected the data from the preservice sample. To do so, I visited two sections of each of the two mathematics methods courses for preservice elementary teachers. In each section, I introduced myself, briefly explained my study, and handed out papers that included a more detailed explanation of the study, as well as a bit.ly link and a QR code that brought participants to the survey.

Due to the insufficient number of inservice respondents during the first round of data collection, extra measures were taken for the second round of data collection. The contact list for the second round of data collection was much larger than the first, consisting of 3,250 email addresses. Additionally, mathematics coaches at various schools were identified on the state's educational agency's website and were confirmed on the school's website. Having access to these coach's email addresses, I was able to email each coach individually and ask them to encourage the teachers with whom they worked to participate in the survey. The new list of individuals was sent the email containing the link to the survey in late May and were sent weekly reminders over the three-week period that the survey was live.

Analysis

Both descriptive and inferential statistics were used for measuring mathematics anxiety and mathematics teacher efficacy in preservice and inservice teachers. To answer the first research question, a two-sample t-test was performed to determine whether the mean R-MARS score for the preservice sample and inservice sample were significantly different. Additionally, a two-sample t-test was performed to determine whether the mean MTEBI scores for preservice and inservice teachers were significantly different. To answer the second research question, responses to the two questions asking teachers to indicate their perceived impact of the mathematics coaches on his or her math anxiety and confidence to teach math were totaled.

To begin the analysis, data from both the inservice survey and preservice survey were exported from Qualtrics into an Excel file. Participants with incomplete instruments were removed from the sample. Items on the R-MARS could be rated from 1- no anxiety to 5- high anxiety. With 20 items total, a participant's score could range from 20 (no anxiety) to 100 (high anxiety). Total R-MARS scores for each participant were calculated, followed by the means for each sample. The scores for each participant were used in the two-sample t-test to compare means for both groups. A two-sample t-test was performed on each item of the R-MARS to determine if there was a statistically significant difference in means between the two groups.

Items on the MTEBI could be rated from 1- strongly disagree to 5- strongly agree. With 21 items total, scores could range from 21 (low confidence). The negatively worded items were reversed scored, such that 1 indicated strongly agreeing, and 5 indicated strongly disagreeing. Total MTEBI scores for each participant were calculated, in addition to the means for each sample. The scores for each participant were used in the two-sample t-test to compare means for both groups.

To answer the second research question, the response frequencies to the two questions asking teachers to indicate their perceived impact of the mathematics coaches on his or her math anxiety and confidence to teach math were totaled.

The third research question was investigated by first creating categories of responses based on the wording that inservice participants used in their written comments about coaching activities and coaching impacts. Responses were then sorted into the relevant categories.

To answer the fourth research question, responses to the R-MARS and MTEBI were used to calculate the correlation coefficient between the instruments for each sample.

Chapter 4: FINDINGS

Introduction

This chapter reports on data findings from a study investigating the difference in reported levels of mathematics anxiety and teacher efficacy between inservice and preservice elementary teachers in a rural northeastern state in the US. The study also investigated the reported impact of mathematics coaches on elementary teachers' mathematics anxiety and teacher efficacy. Finally, the study investigated the elements of working with a mathematics coach that teachers found to be most beneficial for their teaching.

Data were collected through a confidential, anonymous online survey using the Qualtrics survey platform in the spring of 2019. Samples of inservice and preservice elementary teachers completed the Revised Mathematics Anxiety Rating Scale (R-MARS) and the Mathematics Teacher Efficacy Beliefs Instrument (MTEBI). Additionally, inservice teachers from the sample who indicated they currently worked with a mathematics coach completed additional survey questions about their experiences with the mathematics coach. The R-MARS and MTEBI for the preservice and inservice versions are provided in appendices A and B respectively.

The findings from this survey study are presented by research question. The research questions framing this study were:

1. How do the reported levels of mathematics anxiety and mathematics teacher efficacy compare between inservice elementary teachers and preservice elementary teachers?
2. What was the reported impact of mathematics coaches on inservice elementary teachers' anxiety towards mathematics and confidence to teach mathematics?

3. What aspects of working with a mathematics coach do elementary inservice teachers report to be the most beneficial?
4. What is the relationship between mathematics anxiety and mathematics teacher efficacy for inservice elementary teachers and preservice elementary teachers?

Research Question 1A. How do the reported levels of mathematics anxiety compare between inservice elementary teachers and preservice elementary teachers?

A two-sample t-test was performed on each item of the R-MARS to compare anxiety levels between the inservice and preservice teacher samples. Preservice teachers reported significantly higher levels of anxiety on 12 of the 20 items on the R-MARS (p-value less than 0.01). These included two items involving assessment in the classroom, as well as items such as "receiving your final grade in the mail" and "taking the mathematics section of a college exam". Preservice teachers also reported higher levels of anxiety on some of the items with alternate wording, including items about subtraction problems, addition problems, division problems, and algebraic equations. Despite my attempts to compare the items by using similar wording, these last four items were still written from the perspective of a teacher for the inservice sample, and from the perspective of a student from the preservice sample. Thus, the results may indicate that mathematics anxiety occurs more frequently for students in the classroom, than for teachers in the classroom. Additionally, this may mean that someone who experienced mathematics anxiety as a student doesn't necessarily experience it to the same degree as a teacher. Table 4.1 displays the 12 items from the R-MARS where there was a statistically significant ($p = 0.01$) difference in the mean scores between the inservice sample and preservice sample.

Table 4.1

R-MARS items with statistically significant differences in means (p = 0.01).

Item Items in parentheses indicate wording for the preservice version of the instrument.	**Inservice** **n=174**	**Preservice** **n=51**
Being given a "pop" quiz in math class.	3.31	3.90
Thinking about an upcoming math test one day before.	3.07	3.65
Receiving your final grade in the mail.	3.07	3.61
Taking the mathematics section of a college entrance exam.	3.06	3.47
Signing up for a math-focused professional development session (Signing up for a math course).	1.55	2.33
Listening to another teacher or student explain a math formula (Listening to another student explain a math formula).	1.55	2.43
Participating in a math-focused professional development session (Walking into a math course).	1.52	2.35
Demonstrating to my students how to solve a division problem on the board (Being given a set of division problems to solve).	1.43	1.71
Watching another student or teacher work through an algebraic equation on the board (Watching a teacher work on an algebraic equation on the blackboard).	1.37	2.02
Reading a cash register receipt after your purchase.	1.18	1.82
Demonstrating to my students how to solve a subtraction problem on the board (Being given a set of subtraction problems to solve).	1.15	1.37
Demonstrating to my students how to solve an addition problem on the board (Being given a set of numerical problems involving addition to solve on paper.)	1.11	1.47

Eight items, not shown in table above showed no statistically significant difference in mean level of reported anxiety. Five of the eight items, "studying for a math test", "thinking about an upcoming math test one week before", "thinking about an upcoming math test one hour before", "taking a final exam in a math course", and "taking a quiz in a math course" involving math assessment provoked some of the highest levels of anxiety for both teacher samples. These results show that mathematics assessments evoke feelings of anxiety, even for someone who is no longer a student. Further, this finding suggests that those who felt anxious in situations as students do not feel as anxious in situations as teachers.

Two of the items with no significant difference were items with different wordings for each sample. The first of the two items was written as “selecting a new math textbook for my students” for the inservice teachers, and as “buying a new math textbook” for the preservice teachers. The second item was written as “demonstrating to my students how to solve a multiplication problem on the board” for the inservice sample, and “being given a set of multiplication problems to solve” for the preservice sample. These two items, despite having similar mean scores, are challenging to compare. The implications of a teacher purchasing a textbook versus a student purchasing a textbook are considerably different. I would have predicted that choosing a textbook as a teacher would have been a more stressful experience than as a student, especially for someone with a limited grasp on the elementary mathematics curriculum. That being said, that item did evoke the most anxiety in inservice teachers out of all of the items involving scenarios they face as a teacher. It may also be worth mentioning that many elementary teachers may not decide which textbook their school uses, and cannot base their response to that question on personal experience. Similarly, the scenario described above of demonstrating multiplication problems as a teacher may perhaps reflect a less daunting task than solving multiplication problems as a student. The eighth item, “realizing you have to take a certain amount of math credits to fulfill requirements in your major” which used the original wording for both samples, provoked moderate amounts of anxiety for the two groups.

Inservice teachers reported the highest levels of anxiety on items where they were asked to recall their most recent experience in a mathematics course, such as “taking a final exam in a math course”, “being given a pop quiz in a math course”, “thinking about an upcoming math test one hour before”, “thinking about an upcoming math test one day before”, and “taking a quiz in a math course”.

Inservice teachers reported the lowest levels of anxiety on items that involved classroom teaching, such as “demonstrating to my students how to solve an addition (or, subtraction, multiplication, division) on the board”, “listening to another teacher or student explain a math formula”, or “watching another student or teacher work through a math problem on the board”. These results indicate that inservice teachers feel less anxious about aspects of teaching mathematics than they do about being tested on mathematics themselves. Their experience teaching mathematics most likely reduced anxiety they may have had towards teaching mathematics.

Similar to inservice teachers, preservice teachers reported the highest levels of anxiety on assessment related items such as “taking a final exam in a math course”, “being given a pop quiz in math class”, “thinking about an upcoming math test one hour before”. This sample reported the lowest levels of anxiety of items including “being given a set of multiplication problems to solve”, “being given a set of subtraction problems to solve”, and “being given a set of addition and subtraction problems to solve”.

Lastly, preservice teachers reported an average mean score of 54.04 across all items on the R-MARS, while inservice teachers reported an average mean score of 45.02 (higher scores indicate higher levels of math anxiety), indicating a significantly higher average level of math anxiety among preservice teachers compared to inservice teachers. It seems reasonable that an inservice teacher’s anxiety towards mathematics would be lower than a preservice teacher, given their experience with the content as a teacher. Overall, the items involving mathematics as a student seemed to evoke the most anxiety for both samples. With all of the items on the preservice version of the R-MARS written from the student perspective, it seems logical that preservice teachers' overall scores on the R-MARS would be on the higher end of the scale for mathematics anxiety.

Research Question 1b. How do the reported levels of mathematics teacher efficacy compare between inservice elementary teachers and preservice elementary teachers?

A two-sample t-test ($p = 0.01$) was performed on each item of the Personal Mathematics Teaching Efficacy (PMTE) to compare mean levels of personal mathematics teacher efficacy between inservice and preservice elementary teachers. The results showed that inservice teachers reported significantly higher levels of efficacy on 10 of the 13 items. There was no statistically significant difference in the reported level of efficacy for the following PMTE items, "I will continually find better ways to teach mathematics", "when teaching mathematics, I usually welcome student questions" and "I am not very effective in monitoring mathematics activities". Both samples reported the highest levels of efficacy on the first two items mentioned above. Table 4.2 displays the items from the PMTE subscale in which inservice teachers reported significantly higher levels of efficacy.

Table 4.2

PMTE items with statistically significant differences in means ($p = 0.05$).

Item Parentheses indicate wording for preservice version of PMTE.	In. n=174	Pre. n=51
I wonder if I have the necessary skills to teach mathematics.	4.20	2.69
Even if I try very hard, I will not teach mathematics as well as I will most subjects.	4.30	3.29
Given a choice, I would not invite the principal to evaluate my mathematics teaching.	4.26	3.41
I know how to teach mathematics concepts effectively.	4.21	3.39
I do not know what to do to turn students on to mathematics.	3.94	3.18

Table 4.2 Continued

I find it difficult to use manipulatives to explain to students why mathematics works. (I will find it difficult to use manipulatives to explain to students why mathematics works.)	4.27	3.71
When a student has difficulty understanding a mathematics concept, I am usually at a loss as to how to help the student understand it better.	4.24	3.67
I understand mathematics concepts well enough to be effective in teaching elementary mathematics.	4.49	3.94
I am typically able to answer students' questions. (I will typically be able to answer students' questions.)	4.59	4.18
I generally teach mathematics ineffectively.	4.46	4.10

For the PMTE, inservice teachers reported the lowest levels of efficacy on items such as "I am not very effective in monitoring mathematics activities" and "I do not know what to do to turn students on to mathematics". Results from the first item may suggest that teachers may have challenges with learning activities that venture away from traditional instruction. This trend may be associated with not being able to turn students on to mathematics, as that may require engaging, innovative, and possibly fun learning experiences. Inservice teachers reported the highest levels of efficacy for items such as "when teaching mathematics, I usually welcome student questions", "I will continually find better ways to teach mathematics", "I am typically able to answer students' questions", and "I understand mathematics concepts well enough to be effective in teaching elementary mathematics".

Preservice teachers reported the lowest levels of efficacy on items such as "I wonder if I have the necessary skills to teach mathematics", "Even if I try very hard, I will not teach mathematics as well as I will most subjects" , as well as "I do not know what to do to turn students on to mathematics." This sample reported the highest levels of efficacy on items such as "I will continually find better ways to teach mathematics", "I understand mathematics concepts well enough to be effective in teaching elementary mathematics", "when teaching mathematics, I will usually welcome student questions", and "I will typically be able to answer students' questions." While the preservice responses may indicate that teachers are entering the field feeling apprehensive about their ability to teach mathematics, there appears to be an improvement in confidence as they gain experience. This is evidenced by the item with the largest discrepancy between the two samples: "I wonder if I have the skills necessary to teach mathematics". Alternatively, it is possible that the inservice teachers who responded to the survey were already confident to teach mathematics when they entered the classroom as teachers.

Overall, inservice teachers reported a mean score of 56.28 on the PMTE subscale, while preservice teachers reported a mean score of 48.59 (higher scores indicate higher levels of efficacy), indicating a statistically significant higher average score on efficacy for inservice teachers compared to preservice teachers. A two-sample t-test ($p = 0.01$) on each item of the Mathematics Teaching Outcome Expectancy (MTOE) subscale showed statistically significant differences in reported levels of confidence on one of the eight items. Preservice teachers reported significantly higher levels of agreement towards the statement "if students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching." Table 4.3 displays results for items from the MTOE subscale where there were no statistically significant differences in reported levels of efficacy between the two samples:

Table 4.3

MTOE items with no statistically significant difference in means (p = 0.01.)

Item	**Inservice n=174**	**Preservice n=51**
When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.	3.53	3.71

Table 4.3 Continued

When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	4.13	4.23
The inadequacy of a student's mathematics background can be overcome by good teaching.	3.94	4.12
When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher.	4.06	4.00
The teacher is generally responsible for the achievement of students in mathematics.	3.79	3.71
Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	3.78	3.80
If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	3.68	3.80

Inservice teachers reported the highest levels of agreement on statements such as "when the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach," and "when a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher." Inservice teachers reported the lowest levels of efficacy towards the statement "if students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching."

Preservice teachers reported the highest levels of efficacy towards statements including "when the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach," and "the inadequacy of a student's mathematics background can be overcome by good teaching." Preservice teachers reported the lowest levels of efficacy towards the statement "If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching."

Inservice teachers reported an average mean score of 29.95 on the MTOE subscale, while preservice teachers reported an average mean score of 30.82 (higher scores indicate higher levels of efficacy), showing essentially equivalent levels of efficacy for the two teacher samples on the MTOE scale. It is possible that preservice teachers overestimated their efficacy towards the outcomes of mathematics teaching, because they haven't yet worked in a school, and may not have been exposed to the variety of factors that can influence a student's learning of mathematics, aside from the teacher themselves. Overall, inservice teachers reported higher levels of mathematics teaching efficacy, reporting a mean score of 86.23 on the entire MTEBI, compared to a mean score of 79.41 for the preservice teachers. Again, these results may indicate that elementary teachers' efficacy to teach mathematics improves with experience. These results seem logical, as one might expect a person's efficacy in the context of their career would increase the longer they work in that field. When grouped by years of experience (Table 4.4.), the MTEBI scores increase with more experience. The biggest discrepancy between mean MTEBI scores was between the 0-2 and 3-5 years of experience teacher groups. It seems reasonable that a teacher's confidence would grow faster in their first five years of teaching than in later years of teaching.

Table 4.4

Mean inservice MTEBI scores, grouped by years of experience (n=174).

Years of Experience	0-2 (n=21)	3-5 (n=30)	6-10 (n=27)	11-20 (n= 43)	21+ (n=53)
MTEBI Score	79.50	85.26	87.04	87.04	87.65

Research Question 2: What was the reported impact of mathematics coaches on elementary teachers' anxiety towards mathematics and confidence to teach mathematics?

To answer the second research question, inservice teachers were first asked to indicate whether or not they currently worked with a mathematics coach. A total of 66 of the 174 inservice teachers (about 38%) indicated working with a math coach. All 66 completed the additional survey items asking about their experiences with the math coach. Using the same scale (1=large negative impact to 5=large positive impact), participants were asked to "indicate the extent to which you believe working with a math coach impacted your anxiety towards mathematics" and "indicate the extent to which you believe working with a math coach impacted your confidence to teach mathematics" .

On these items, 66% of respondents reported positive impacts of working with a coach on their mathematics anxiety, while 79% reported positive impacts on their confidence to teach mathematics. However, 32% reported no impact on their anxiety, and 20% reported no impact on their confidence. Overall, these findings indicate positive perceptions of impacts from coaching on teachers' mathematics anxiety and efficacy for a majority of the teachers, but stronger positive impacts for efficacy than for reducing teachers' anxiety in mathematics. One potential explanation for the lower impact on anxiety is the possibility that some inservice teachers may not have had anxiety towards teaching mathematics, and thus didn't perceive that as an outcome of working with the mathematics coach. Therefore, these respondents may have been more inclined to feel like their confidence increased as a result of working with the coach. It seems possible that any teacher with any amount of experience can feel an increase in confidence after a positive professional development experience. However, only those who have experienced mathematics anxiety previously would perceive any reduction in anxiety to be an outcome of working with a coach.

Alternatively, it may be that there is a percentage of highly math anxious teachers who, despite positive experiences with the mathematics coach, might not feel any less anxious about the subject. These teachers' confidence levels to teach could be improved while still remaining mathematically anxious. Table 4.5 presents the distribution of responses.

Table 4.5 Reported impact of mathematics coaching on elementary teachers' anxiety and confidence towards teaching mathematics (n=66).

	Large Positive	Small Positive	No Impact	Small Negative	Large Negative
Anxiety	34.8% (n=23)	31.8% (n=21)	31.8%(n=21)	0% (n=0)	1.5% (n=1)
Confidence	42.4% (n=28)	36.4% (n=24)	19.7% (n=13)	0% (n=0)	1.5% (n=1)

Research Question 3. What aspects of working with a mathematics coach do teachers report to be the most beneficial?

Out of the 66 teachers who reported working with a mathematics coach, 33 (50% reported that they were required to work with the coach. Inservice teachers who reported working with a mathematics coach were asked to respond to a multiple-choice item regarding the various ways they worked with a coach. Teachers were able to select more than one option. Table 4.6 shows the various ways in which teachers reported they had worked with a coach.

Table 4.6 Response frequency for types of interactions teachers had with coach (n=66)

Type of Interaction	Lesson Planning	Lesson modeling or demonstration	Co-teaching	Content Support	Observations of your teaching by mathematics coach	Other
Number of Responses	27	34	23	55	28	13

These teachers were also asked to indicate the frequency with which they worked with a coach. Table 4.7 shows the frequency of interactions with the coaches. Two of the teachers who indicated working with a coach did not respond to this item.

Table 4.7 Response frequencies for number of types of interactions (n=64)

Number of Interactions	2x per week	1x per week	3x per month	2x per month	1x per month	2x per year	1x per year
Number of Responses	6 (9.4%)	2 (3.1%)	13 (20.3%)	8 (12.5%)	16 (25%)	14 (21.8%)	5 (7.8%)

Finally, inservice teachers who reported having worked with a mathematics coach were asked to respond to an open-ended question on their survey which asked them to “indicate which aspect of working with a mathematics coach is most beneficial to your teaching”. Of the 66 teachers who reported working with a mathematics coach, 54 (82%) responded to this item. The qualitative responses were analyzed by coding keywords and then categorizing the different types of benefits teachers described. On the previous page of the survey, a number of activities were listed for teachers to select which ones they engaged in with a math coach. Some of the comments did not match the same wording used on the survey, so the categories of responses are broader than what was listed on the survey. Ultimately, six primary categories emerged through analysis and included: “observation and feedback”, “co-teaching and co-planning”, “modeling”, “curriculum and content support”, “supplemental resources”, and “data collection”. Additionally, there was a seventh “other” category for responses that did not fit into the other six categories. While these categories were based on the actual language used by the teachers in their written comments, there is some overlap with the categories of coaching described by Kurz (2017) such as, “planning”, “demonstrating”, “critiquing”, “evaluating” and “adjusting”. This overlap will be discussed further in the following chapter. Table 4.8 shows examples of responses for each category.

Table 4.8

Coaching supports mentioned to be most beneficial to teaching (n= 53).

Co-teaching and Co-planning (n=17) “lesson planning and modeling” “I co-taught with my math coach which was very beneficial, and she did an amazing job of helping me understand the new math curriculum.” “bouncing ideas off of her for things to do in my lessons” “Pacing, planning, & grade level meetings”

Table 4.8 Continued

Curriculum and Content Support (n=14) "understanding the curriculum" "Having someone who knows more about the content than I do and can help me" "curriculum clarification" "Content ideas, going over lesson plans before and after conducting lessons"
Observation and Feedback (n=7) "nonjudgmental feedback "being observed and getting feedback" "observations and feedback"
Supplemental Resources (n=7) "Finding resources to help teach content" "Getting supplemental materials" "The resources he gives me are amazing!" "finding challenging activities for gifted math students, helping with online resources. some assessments, tweaking lessons to better meet needs"
Modeling (n=6) "observing different ways to do math" "content support and lesson modeling" "lesson planning and modeling"
Data Collection (n=2) "Seeing the big picture, thinking about student data" "Data collection and creating individual student goals"
Other (n=6) "Having someone to discuss success, as well as challenges and concerns" "She is able to pull and work with my lowest math students providing push in support to meet their needs" "importance"

Many of the comments also fit into multiple categories. Of the 54 responses to this question, only two were negative. These comments mentioned not finding significant value in their experiences with coaches, and felt the meetings were not a valuable use of time.

"Co-teaching and co-planning" was the category with the most responses, followed by "curriculum and content support", "supplemental resources", "observation and feedback", "modeling" and finally, "data collection". The distribution of responses may point to aspects of teaching that elementary teachers struggle with. Additionally, many teachers indicated that they found curriculum and content support from coaches to be the most beneficial to their teaching.

This may be evidence that elementary teachers have weaknesses understanding the content and curriculum.

Research Question 4. What is the relationship between mathematics anxiety and mathematics teacher efficacy for inservice elementary teachers and preservice elementary teachers?

The total scores of the R-MARS and MTEBI were correlated for each sample to determine the relationship between mathematics anxiety and mathematics teacher efficacy. Both samples reported a semi-strong, negative correlation between mathematics anxiety and mathematics teacher efficacy. The correlation coefficient for the inservice sample was -0.31, while the correlation coefficient for the preservice sample was a slightly stronger -0.41. The correlation coefficient for the preservice sample is similar to those calculated in studies that have used the R-MARS and the MTEBI (Gresham, 2009; Swars & Daane, 2006).

It seems reasonable that as the level of mathematics anxiety for an individual increases, their efficacy towards teaching the subject would. Alternatively, as teachers gain experience in the field, their efficacy towards teaching increases and their anxiety towards mathematics decreases. As mentioned earlier, inservice teachers reported the highest levels of anxiety on items that placed them in the student role. I hypothesize that there would be a stronger correlation if more items on the R-MARS were written from a teacher's perspective, because their anxiety towards student situations does not appear to have subsided with experience. By contrast, all of the items on the MTEBI were written from the perspective of the teacher.

Overall, the results of this survey study indicate that inservice elementary teachers are more comfortable with elementary mathematics than are preservice teachers, which is likely due to experience. Inservice teachers reported significantly higher levels of efficacy towards teaching mathematics. Further, there was a significant increase in efficacy in teachers within their first five years of teaching. Additionally, inservice teachers reported the most anxiety on items related to assessments as a student, and the lowest levels of anxiety on items written from the perspective of the teacher. This suggests that anxiety may be more of an issue as a student than as a teacher. Teachers may face fewer situations that evoke mathematics anxiety as a teacher than they would as a student. However, both inservice and preservice teachers reported fairly high levels of anxiety regarding mathematics, particularly in the area of being assessed on their mathematics knowledge.

In the final chapter, I will discuss my hypotheses surrounding my analysis. I will connect the results of my analysis with the previous literature, and conclude the chapter with the limitations, significance, and implications of my study.

Chapter 5: DISCUSSION

Introduction

The purpose of this study was to investigate the levels of mathematics anxiety and mathematics teacher efficacy and the correlation between the two in both preservice and inservice elementary teachers. Past research has indicated that (Beilock et al., 2010; Bush, 1989) elementary teachers with high levels of mathematics anxiety were at risk of passing their anxiety to their students (Austin, Wadlington, & Bitner, 2001). Mathematics anxiety could be one factor that contributes to preservice elementary teachers' beliefs that they do not have the ability to teach mathematics effectively (Bursal & Paznokas, 2006). This study also investigated the impact of mathematics coaches on teachers' attitudes towards mathematics. This chapter will discuss the study's findings from data collected in Spring 2019. The rest of this chapter includes a discussion of the results in the broader context of the study and the literature, followed by the limitations, significance of the study, and implications.

Elementary Teachers and Mathematics Anxiety

Elementary teachers suffer from high levels of mathematics, which can have negative implications on their teaching (Beilock et al., 2010; Bush, 1989). Prior research has indicated that many preservice elementary teachers have feelings of mathematics anxiety that can be traced back to negative experiences with mathematics as a student (Burton, 2012; Cornell, 1999; Trujillo & Hadfield, 1999). Without any intervention, these feelings of anxiety most likely stay with them as inservice teachers (Boyd et al., 2014; Gresham, 2018; Hadley & Dorward, 2011). One result of this trend is that these anxieties towards learning mathematics can have negative consequences for their teaching of mathematics (Harper & Daane, 1998).

This study found that preservice teachers generally reported higher levels of mathematics anxiety than did inservice teachers. The preservice teachers reported statistically significantly higher levels of anxiety on 13 of the 20 items on the RMARS. Additionally, the preservice sample had a higher average score on the RMARS, indicating higher levels of anxiety.

This study shows that experience with mathematics in the role of an inservice teacher may have reduced teachers' anxiety. Inservice teachers reported the highest levels of anxiety on items framed from the student perspective, and their lowest levels of anxiety on items related to teaching mathematics, such as "demonstrating to my students how to solve an addition problem on the board" and "demonstrating to my students how to solve a division problem on the board". Because these survey items were re-written for the current study to reflect a teacher's perspective, the results for these items cannot be compared with prior research using the original wording on the RMARS that reflected a student's perspective.

It may be that because preservice teachers are experiencing a mathematics course firsthand as students, they may have more prevalent feelings of anxiety, and thus reported higher levels. Both preservice and inservice teacher samples reported the highest levels of anxiety on items related to being assessed in mathematics such as "thinking about an upcoming math test", "being given a pop quiz in a math class" and "receiving your final grade in the mail". Prior studies have not reported what items on the RMARS provoked the most anxiety, but rather an overall score. However, situations in which students are tasked with finding a correct answer in a certain amount of time, like assessments, can cause a fear of failure, and thus evoke anxiety (Finlayson, 2014; Geist, 2010). While a first-year teacher may have fears of failing, their fears likely ease after many repetitions with a concept. And, when preservice teachers become teachers, they are experiencing mathematics as an instructor and no longer as a student being assessed. Therefore, the lack of assessment in mathematics for inservice teachers may contribute to their reduced levels of anxiety.

Elementary Teachers and Efficacy

Previous research indicates that many preservice elementary teachers believe they do not possess the ability to teach mathematics effectively (Bursal & Paznokas, 2006). However, there is no current literature regarding teacher efficacy in inservice teachers. When comparing efficacy between the preservice and inservice sample, this study found that inservice teachers generally reported higher levels of personal efficacy towards teaching mathematics. Inservice teachers reported statistically significantly higher levels of efficacy on 10 of the 13 items on the Personal Mathematics Teaching Efficacy (PMTE) subscale. While previous studies used the MTEBI with preservice populations, this study is the first to compare the levels of efficacy between inservice and preservice teachers.

The two samples showed the largest differences in confidence on the items “I wonder if I have the necessary skills to teach mathematics”, “even if I try very hard, I will not teach mathematics as well as I will most subjects”, and “given a choice, I would not invite the principal to evaluate my mathematics teaching.” Within the inservice sample, respondents in their first two years of teaching had considerably lower average scores on the MTEBI than those with three or more years of experience.

These results may further indicate that confidence to teach elementary mathematics increases with experience. Preservice teachers, in addition to having feelings of mathematics anxiety, also have little or no experience teaching elementary mathematics in the classroom. Therefore, it seems likely that these future teachers do not have strong feelings of confidence about their mathematics teaching.

Mathematics Anxiety and Math Teacher Efficacy

Preservice elementary teachers tend to link their mathematics anxiety to a lack of self-confidence (Finlayson, 2014). Multiple studies have reported negative correlations between mathematics anxiety and mathematics teacher efficacy in preservice elementary teachers (Bursal & Paznokas, 2006; Gresham, 2009; Swars & Daane, 2006). This study found the correlation between mathematics anxiety and mathematics teacher efficacy to be stronger for preservice teachers than for inservice teachers, with coefficients of -0.41 and -0.31 respectively. The preservice correlation coefficient is consistent with previous studies for preservice teachers, showing that the higher one's levels of mathematics anxiety are, the lower their levels of mathematics teacher efficacy will be. This association between anxiety and efficacy is important because other studies have shown that an elementary teacher's efficacy towards teaching mathematics can have implications on their methods of instruction, as well as student achievement (Swars & Daane, 2006).

The Impact and Roles of Mathematics Coaches

The amount of time a teacher spends with a mathematics coach can be a predictor of success in the collaboration, and more time working with a coach can produce larger positive impacts for teachers. Frequent, in-person collaboration with mathematics coaches is important for the development of teacher confidence (Taylor, 2017). One study found that if the coach and teacher didn't spend enough time together, the teacher didn't feel comfortable enough to have an honest conversation about their teaching practice (Gellert & Gonzalez, 2011). Another study found that the more time the teacher spent with the coach, the more likely teachers were to make changes to their instruction (Drust, 2015).

A little over half (55%) of the teachers who worked with coaches reported working with the coach one or fewer times each month. Only 12% of teachers reported working with a coach on a weekly basis. Interestingly, this study found no association between frequency of meetings, and impact on anxiety or self-efficacy for the teachers. The lack of association found in this study could be due to the skewed distribution of reported coaching impacts, with the majority of teachers reporting positive impacts.

Only 38% of inservice teachers reported that they worked with a mathematics coach, which may indicate that this form of professional development is not available to the majority of elementary teachers in the state where the study was conducted. "Content support" was the most common way teachers reported working with coaches, followed by "lesson modeling or demonstration", "observation of your teaching by the coach", "lesson planning", "co-teaching", and "other".

Prior research has also indicated that lesson planning is an effective way for coaches and teachers to collaborate. This form of collaboration helps the coach understand the teachers' backgrounds and beliefs about mathematics (Zuspan, 2013), in addition to helping teachers develop a better understanding of the K-5 curriculum (Green & Kent, 2016), After experiencing the benefits of collaborating on lesson plans with coaches, teachers may be more likely to collaborate with other teachers in the future.

This study found evidence that teachers believe lesson planning is an effective form of collaboration between teachers and mathematics coaches. Lesson planning is similar to some of the coaching actions described by Kurz et al. (2017). These actions are similar to "planning" and "adjusting" from the Kurz et al. framework. Inservice elementary teachers reported most frequently "co-teaching and co-planning" as the most beneficial form of collaboration with the mathematics coaches. This category included written responses such as: “I co-taught with my coach which was very beneficial and she did an amazing job of helping me understand the new math curriculum”, “bouncing ideas off of her for things to do in my lessons”, and “Pacing, planning, & grade level meetings”.

“Curriculum and content support” was the second most frequently mentioned form of coaching cited as most beneficial, and the responses included comments, such as: “having someone who knows more about the content than I do and can help me”, “content ideas, going over lesson plans before and after conducting lessons”. “understanding the curriculum”, and “curriculum clarification”. This category did not closely mirror any of the coaching actions described by Kurz et al. (2017).

Only seven teachers reported “observation and feedback” as the most beneficial aspect of working with a coach. This category is closely related to the “critiquing” and “evaluating” actions in the Kurz et al. framework (2017). The low number of responses in this category may be evidence of the importance of comfort in the teacher-coach relationship.

The Kurz et al. framework (2017) includes three coaching actions that were not mentioned by teachers as being the most beneficial form of interaction with a coach in the current study: questioning, assessing, and setting goals. While these coaching actions weren’t explicitly mentioned by teachers, it is likely that these actions were used by coaches. Setting goals seems like an action that would be valuable to make at the beginning of collaboration between the teacher and the coach. By setting goals, the teacher has a chance to reflect on areas of teaching they might need to improve and allows the coach to better meet the needs of the coach. During this goal setting process, it is also likely that the coach uses questioning to help guide the teacher’s reflection on their practices. It is also likely that goal setting was part of the coaching support on lesson planning and help with curriculum and content. And questioning would have occurred through coaching observations and feedback. Kurz et al. also describe assessing as “synthesizing information and data to identify coaching needs for teachers and students”. Again, it is likely that many coaches used teacher or student data to determine areas of focus for the teacher. It is possible that this sort of action might be completed at the beginning of the collaboration, and not viewed as the most beneficial action by the coach.

It is unclear why the inservice teachers in this study did not mention these other types of coaching supports in their written comments. It may be that teachers did not receive those types of coaching supports. However, it is more likely that they did. The responses may indicate that elementary teachers have weaknesses in terms of implementing effective lesson plans. This may indicate that the apprehension elementary teachers feel towards mathematics may affect their ability to effectively plan mathematics lessons. These results may also indicate that teachers may be able to plan lessons effectively but may not understand the content well enough to implement the lessons successfully.

This study also found that mathematics coaches had primarily positive impacts on teachers’ anxiety towards mathematics and their efficacy in teaching math. Only one respondent reported a negative impact on their anxiety towards mathematics. However, a third of the teachers (32%) reported no impact on their anxiety towards mathematics as a result of working with a coach. Teachers also reported that their confidence to teach mathematics was positively impacted by the mathematics coaches. Only 20% reported no impact, and one participant reported a large negative impact. This is the first study that specifically reports on the impact of mathematics coaches on elementary teachers’ mathematics anxiety and confidence to teach mathematics.

Interestingly, about 67% of teachers who worked with a coach reported positive impacts (either large or small) on their anxiety, while about 79% reported positive impacts on their confidence to teach mathematics. These results tell us that elementary teachers may view mathematics anxiety as less of an obstacle to their teaching. This is supported by inservice teachers reporting the highest levels of anxiety on items involving experiencing mathematics as a student. This may indicate that there are other factors contributing to a teacher's lack of confidence, aside from mathematics anxiety.

Limitations

Methodology

Due to the subject matter of the study, and the self-selection of participants, it is possible that teachers with high levels of mathematics anxiety chose to avoid the survey all together after learning the study involved the topic of mathematics anxiety. Those preservice and inservice teachers who doubt their abilities as elementary mathematics teachers may have felt inclined to avoid the survey. Similarly, it is possible that those with negative experiences with a mathematics coach would avoid a survey inquiring about their experiences with coaching. Thus, as with any survey, there is some potential for selection bias and we do not know if non-responding teachers would differ in their responses.

Additionally, the study instruments were only administered one time. A pre- and post-study administration of the two survey instruments or use of a comparison or control group of inservice teachers, would allow us to make stronger conclusions about the impact of the coaching support for inservice teachers. The study relied on teachers' perceptions about coaching impacts on anxiety and efficacy, and we do not know what their anxiety and efficacy levels were prior to working with a coach.

Additionally, because the items on the RMARS were written from the student's perspective, it was challenging to compare inservice teachers' levels of mathematics anxiety to the preservice sample. To account for this, future research may consider re-orienting items to match more closely with situations that inservice teachers may face during classroom instruction that could provoke mathematics anxiety.

The majority of the data collected were quantitative. Qualitative data were limited to two items on the survey, where teachers asked about other coaching supports they had received and what they perceived to be the most beneficial aspect of working with the coach. To better understand the relationships and dynamics of the coach-teacher relationships, and more specifically how coaching was provided, qualitative interviews would have provided more in-depth data. Interviews would allow us to further explore not only the positive impacts of coaching, but perhaps the negative impacts as well. There are many possible outcomes of the coaching model, but the survey was focused on outcomes related to anxiety and confidence. Qualitative data could provide specific examples to better understand how coaching contributes to reduced anxiety and increased efficacy for teachers.

Sample Size

The inservice sample (n= 174) was more than triple the size of the preservice sample (n=51). Samples that are closer in size would allow us to make stronger conclusions when comparing mathematics anxiety and mathematics teacher efficacy between the two samples. Both samples were relatively small.

The preservice sample only consisted of participants from one post-secondary institution. While the preservice results were consistent with prior research, there are a number of other teacher credentialing universities in the state where the study was conducted. The experience of preservice elementary teachers at these schools may be different than for the university where the study was conducted.

A larger inservice sample would give us a more accurate picture of the levels of mathematics anxiety and mathematics teacher efficacy among practicing teachers. As noted above, this sample may not include many teachers who have strong feelings of anxiety, due to the self-selection of participants. Additionally, the study did not collect geographical data for the inservice sample. There are other demographic factors influencing teachers such as school size, type of community (urban, rural) that could not be examined in this study.

Significance of the Study

The findings from this study add to the current knowledge on mathematics anxiety and mathematics teacher efficacy in elementary teachers. Mathematics anxiety and mathematics teacher efficacy are both constructs that have been studied frequently for preservice teachers, but not for inservice teachers. This study begins to fill that gap in the research literature by comparing the levels of anxiety and teacher efficacy between the two populations of teachers—preservice and inservice elementary teachers. Similarly, the correlation coefficient between the mathematics anxiety and mathematics teacher efficacy has been reported for preservice elementary teachers in previous studies, but not for inservice teachers (Swars & Daane, 2006; Gresham, 2009). This study makes a significant contribution to the research by examining that correlation for inservice teachers. It is valuable to know if the same type of correlation holds for inservice teachers as well as for preservice teachers. This study found that inservice teachers with higher levels of mathematics anxiety may also have lower levels of efficacy towards teaching mathematics, but the strength of this correlation is still stronger for preservice teachers than for inservice teachers.

This study also makes a significant contribution to the existing knowledge on mathematics coaches and their impact on anxiety and confidence in elementary teachers. The current literature on instructional coaching tends to focus on impacts on teaching practices and student outcomes (Campbell & Malkus, 2011; Dobbins and Simon, 2010), but does not examine the impacts of coaching on teachers' anxiety and confidence to teach mathematics. This study helps to address that gap in the research as well. Additionally, the implementation of elementary mathematics coaches is a relatively recent trend in some states, such as the state where the study was conducted. This study provides timely data to understand teachers' perceptions of their coaching supports, and where coaching has been most beneficial to them. The results also indicate that a relatively small percentage of teachers in in this state may have access to math coaching, which suggests that programs are needed to prepare more teachers to work in the role of math coach.

Reflections on Social Constructivism in Teacher Learning

Given the quantitative nature of the study, it is challenging to connect elements of the teacher-coach relationship with the suggestions offered by Adams (2006). Adams suggests that teachers "seek to engage learners in tasks seen as ends in themselves in consequently having implicit worth." The tasks that the elementary teachers (learners) engaged in with the coaches, such as lesson planning, lesson modeling, and content support, were all tasks that were immediately perceived as useful and valuable for the teachers. Therefore, these teachers were perhaps more willing to engage in the learning process with coaches than they would be to participate in other forms of different professional development they may view as less helpful.

Adams' other suggestions were likely elements of the coaching models used by the participants in the study, but the methodology did not allow for those connections to be made.

These suggestions included “focus on learning not performance”, “view learners as active co-constructors of meaning and knowledge”, and “establish a teacher-pupil relationship built upon the idea of guidance not instruction”.

Teacher Preparation and Professional Development

This study has implications for preservice and inservice elementary teachers. Consistent with prior research, this study indicates that many prospective elementary teachers are entering the field lacking confidence to teach mathematics. This study also indicates that confidence to teach elementary mathematics increases with teaching experience, and that preservice teachers generally have higher levels of anxiety towards mathematics. It is possible that preservice elementary teachers may need more preparation to teach the mathematics they will be responsible to teach. Two semesters of mathematics methods courses may not be sufficient preparation for someone with an insufficient mathematics background. Inservice teachers, despite their experience teaching mathematics, still have strong feelings of anxiety towards assessment in mathematics, indicating they don’t completely lose their feelings of mathematics anxiety. These findings suggest that inservice teachers need more professional development interventions that are specific to mathematics. If inservice teachers are provided with professional development that reduces their mathematics anxiety, then it is likely that their confidence to teach mathematics will increase. An increase in teacher confidence will likely lead to positive student outcomes.

Furthering that point, this study may indicate a need for specialization in the lower grades. Elementary teachers may be expected to teach multiple subjects, including language arts, history, science and mathematics. As an alternative to hiring a mathematics coach, school districts may consider hiring a teacher who specializes in mathematics to teach certain math classes. Many of the prospective teachers with strong mathematics backgrounds pursue secondary or middle school endorsements. If there were the option of a K-5 mathematics endorsement, then perhaps more teachers with stronger mathematics backgrounds would feel inclined to teach at the elementary level. Policy makers at the state level should consider this option as a way to impose specialization at the elementary grades.

<u>Professional Development and Coaching</u>

This study also has implications for the use of coaching in school districts. There is clearly a need for mathematics-specific professional development for elementary teachers. Mathematics coaches were perceived positively by the participants of this study and were effective in improving teachers' anxiety and confidence towards teaching mathematics. Because preservice teachers are entering the field with higher levels of anxiety and lower levels of confidence, mathematics coaching would be a valuable form of on-going professional development for these teachers. Mathematics coaching that is consistent throughout the school year provides a more effective alternative to "one-day" style professional development sessions (Desimone, 2009; Odden, 2011). Additionally, professional development that is spread over time has been linked to an increase in teachers' pedagogical knowledge (Soliday, 2015).

When hiring a mathematics coach, it is important for principals to consider how the mathematics coach will be received by the teachers (Grant & Davenport, 2009). If possible, it may be in the best interest of the school to hire a mathematics coach internally. In some schools, an elementary teacher might naturally emerge as the go-to teacher for mathematics help. It is important that the elementary teachers feel comfortable asking the mathematics coach for help. If the coach is someone they already know and are comfortable with, then the implementation of a coach may be better received. Alternatively, if the school hires an outside coach, it may take time before the teachers are comfortable seeking help from the coach.

Future Research

This study provides a foundation to better understand the relationship between mathematics anxiety and mathematics teacher efficacy in elementary teachers, as well the effectiveness of mathematics coaching to reduce mathematics anxiety and increase efficacy. In line with the aforementioned limitations of the study, a qualitative study of coaching could provide valuable insight with implications for the training and implementation of these coaches.

Traditional teaching methods have been linked to mathematics anxiety in students (Cates & Rhymer, 2003; Finlayson, 2014; Geist, 2010; Van de Walle, 2004). If new teachers are entering the field with mathematics anxiety, they may be limited in their teaching style (Boaler, 2002). This contributes to the cycle of mathematically anxious teachers teaching students, and possibly passing on some of those anxious feelings and negative perceptions (Austin et al., 2001; Ma, 1999). It is valuable to know if and how a teacher's practices changes as a result of working with a coach. Additionally, we do not know how teachers' views towards mathematics changed while working with a mathematics coach. It is important to know if teachers' perceived value of mathematics changed or if their personal feelings towards the subject change

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Appendix A – PRESERVICE TEACHER SURVEY

1. What is your current major? Please write in your answer below:
2. What year of college are you currently in? Please select your answer from the choices below:
3. With what gender do you identify? Please select your answer.

Mathematics Teacher Efficacy Beliefs Instrument

Please indicate the degree to which you agree or disagree with each statement below by selecting the appropriate choice:
Strongly Disagree   Disagree   Neither Agree nor Disagree   Agree   Strongly Agree

1. When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.
2. I will continually find better ways to teacher mathematics.
3. Even if I try very hard, I will not teach mathematics as well as I will most subjects.
4. When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.
5. I know how to teach mathematics concepts effectively.
6. I will not be a very effective in monitoring mathematics activities.
7. If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.
8. I will generally teach mathematics ineffectively.
9. The inadequacy of a student's mathematics background can be overcome by good teaching.
10. When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher.

11. I understand mathematics concepts well enough to be effective in teaching elementary mathematics.
12. The teacher is generally responsible for the achievement of students in mathematics.
13. Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.
14. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.
15. I will find it difficult to use manipulatives to explain to students why mathematics works.
16. I will typically be able to answer students' questions.
17. I wonder if I have the necessary skills to teach mathematics.
18. Given a choice, I will not invite the principal to evaluate my mathematics teaching.
19. 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.
20. When teaching mathematics, I will usually welcome student questions.
21. I do not know what to do to turn students on to mathematics.

Revised Mathematics Anxiety Rating Scale

Please indicate the level of anxiety you feel about the following statements by selecting the appropriate choice: 1=no anxiety 2 3 4 5= high anxiety

1. Studying for a math test.
2. Taking the mathematics section of a college entrance exam.
3. Taking a quiz in a math course.
4. Taking a final exam in a math course.
5. Thinking about an upcoming math test 1 week before.
6. Thinking about an upcoming math test 1 day before.
7. Thinking about an upcoming math test 1 hour before.
8. Realizing you have to take a certain number of math classes to fulfill requirements in your major.
9. Receiving your final math grade in the mail.
10. Being given a "pop" quiz in math class.
11. Reading a cash register receipt after your purchase.
12. Being given a set of numerical problems involving addition to solve on paper.
13. Being given a set of subtraction problems to solve.
14. Being given a set of multiplication problems to solve.
15. Being given a set of division problems to solve.
16. Buying a math textbook.
17. Watching a teacher work on an algebraic equation on the blackboard.
18. Signing up for a math course.
19. Listening to another student explain a math formula.
20. Walking into a math course.

Appendix B- INSERVICE TEACHER SURVEY

1. In which grades are you currently teaching mathematics? (Select all that apply)
2. Excluding student teaching, how many years have you worked as an elementary or middle school teacher, counting this year? (Select one).
3. What is the highest academic degree you hold? (Select one).
4. With which gender do you identify?
5. Do you currently work with a math coach at your school? (Sometimes referred to as math specialist, or teacher leader)?

   If "no" or "unsure" is selected on question 5.

   If you are feeling anxious or unsure about that mathematics you are required to teach, what resources do you have? (Free response)

   If "yes" is selected on question 5.

Are you required by your school or district to work with a math coach?

a. Yes
b. No
c. Unsure

Including this year, how many years have you worked with a math coach?

- 1 year
- 2 years
- 3 years
- More than 3 years

Approximately how frequently do you work with a math coach?

- 1 time per year
- 2 times per year
- Less than 1 time per year
- 1 time per month
- 2 times per month
- 3 times per month
- 1 time per week
- 2 times per week

Out of the list of activities below, please select the activities in which you engaged with a math coach (select all that apply):

- Lesson planning
- Lesson modeling or demonstration
- Co-teaching
- Content support
- Observations of your teaching by the math coach
- Other

What other activities do you engage in with a math coach? (Free response)

Please indicate which aspect of working with a math coach is most beneficial to your teaching (Free response)

Using the scale below, please indicate the extent to which you believe working with a math coach impacted your anxiety towards mathematics:

1- Large negative impact
2- Small negative impact
3- No impact
4- Small positive impact
5- Large positive impact

Using the scale below, please indicate the extent to which you believe working with a math coach impacted your confidence to teach mathematics:

1- Large negative impact
2- Small negative impact
3- No impact
4- Small positive impact
5- Large positive impact

Mathematics Teacher Efficacy Beliefs Instrument

Please indicate the degree to which you agree or disagree with each statement below by selecting appropriate choice.
1-Strongly Disagree 2- Disagree 3-Neither Agree nor Disagree 4-Agree 5-Strongly Agree

1. When a student does better than usual in mathematics, it is often because the teacher exerted a little extra effort.
2. I will continually find better ways to teacher mathematics.
3. Even if I try very hard, I will not teach mathematics as well as I will most subjects.

4. When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.
5. I know how to teach mathematics concepts effectively.
6. I am very effective in monitoring mathematics activities.
7. If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.
8. I generally teach mathematics ineffectively.
9. The inadequacy of a student's mathematics background can be overcome by good teaching.
10. When a low-achieving child progresses in mathematics, it is usually due to extra attention given by the teacher.
11. I understand mathematics concepts well enough to be effective in teaching elementary mathematics.
12. The teacher is generally responsible for the achievement of students in mathematics.
13. Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.
14. If parents comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.
15. I find it difficult to use manipulatives to explain to students why mathematics works.
16. I am typically be able to answer students' questions.
17. I wonder if I have the necessary skills to teach mathematics.
18. Given a choice, I would not invite the principal to evaluate my mathematics teaching.

19. 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.
20. When teaching mathematics, I usually welcome student questions.
21. I do not know what to do to turn students on to mathematics.

Revised Mathematics Anxiety Scale

For the statements that follow, please think about your most recent experience in a math class and indicate the level of anxiety you felt when you engaged in these different aspects of doing mathematics. 1= No Anxiety 2 3 4 5=High Anxiety

1. Studying for a math test.
2. Taking a quiz in a math course.
3. Thinking about an upcoming math test one week before.
4. Thinking about an upcoming math test one day before.
5. Thinking about an upcoming math test one hour before.
6. Taking a final exam in a math course.
7. Realizing you have to take a certain amount of math credits to fulfill requirements in your major.
8. Being given a "pop" quiz in math class.
9. Receiving your final grade in the mail.
10. Taking the mathematics section of a college entrance exam.

For the statements that follow, please indicate the level of anxiety you feel when you engage in these different aspects of doing mathematics.

1=No Anxiety 2 3 4 5=High Anxiety

1. Reading a cash register receipt after your purchase.
2. Demonstrating to my students how to solve an addition problem on the board.
3. Demonstrating to my students how to solve a subtraction problem on the board.
4. Demonstrating to my students how to solve a multiplication problem on the board.
5. Demonstrating to my students how to solve a division problem on the board.
6. Selecting a new math textbook for my students.
7. Signing up for math-focused professional development session.
8. Listening to another teacher or student explain a math formula.
9. Watching another student or teacher work through a math problem on the board.
10. Participating in a math-focused professional development session.

Appendix C – RMARS MEANS AND STANDARD DEVIATIONS

1=No Anxiety 2 3 4 5= High Anxiety

	IN. (N=174)		PRE. (N=51)	
ITEM	Mean	S.D.	Mean	S.D.
STUDYING FOR A MATH TEST.	2.98	1.32	3.18	1.37
TAKING A QUIZ IN A MATH COURSE.	3.05	1.30	2.86	1.21
THINKING ABOUT AN UPCOMING MATH TEST ONE WEEK BEFORE.	2.62	1.30	2.98	1.26
THINKING ABOUT AN UPCOMING MATH TEST ONE DAY BEFORE.	3.07	1.33	3.65	1.21
THINKING ABOUT AN UPCOMING MATH TEST ONE HOUR BEFORE.	3.29	1.30	3.98	1.14
TAKING A FINAL EXAM IN A MATH COURSE.	3.67	1.30	4.20	1.06
REALIZING YOU HAVE TO TAKE A CERTAIN AMOUNT OF MATH CREDITS TO FULFILL REQUIREMENTS IN YOUR MAJOR.	2.63	1.40	2.80	1.52
BEING GIVEN A "POP" QUIZ IN MATH CLASS.	3.31	1.38	3.90	1.24
RECEIVING YOUR FINAL GRADE IN THE MAIL	3.07	1.39	3.61	1.28
TAKING THE MATHEMATICS SECTION OF A COLLEGE ENTRANCE EXAM.	3.06	1.38	3.47	1.39
READING A CASH REGISTER RECEIPT AFTER YOUR PURCHASE.	1.18	0.62	1.82	1.20

DEMONSTRATING TO MY STUDENTS HOW TO SOLVE AN ADDITION PROBLEM ON THE BOARD	1.11	0.41	1.47	.70
DEMONSTRATING TO MY STUDENTS HOW TO SOLVE A SUBTRACTION PROBLEM ON THE BOARD	1.15	0.51	1.37	0.63
DEMONSTRATING TO MY STUDENTS HOW TO SOLVE A MULTIPLICATION PROBLEM ON THE BOARD.	1.31	0.70	1.41	0.70
DEMONSTRATING TO MY STUDENTS HOW TO SOLVE A DIVISION PROBLEM ON THE BOARD.	1.43	0.84	1.71	0.86
SELECTING A NEW MATH TEXTBOOK FOR MY STUDENTS.	2.14	1.26	2.49	1.31
SIGNING UP FOR MATH-FOCUSED PROFESSIONAL DEVELOPMENT SESSION.	1.55	0.98	2.33	1.35
LISTENING TO ANOTHER TEACHER OR STUDENT EXPLAIN A MATH FORMULA.	1.54	0.93	2.43	1.20
WATCHING ANOTHER STUDENT OR TEACHER WORK THROUGH A MATH PROBLEM ON THE BOARD.	1.37	0.73	2.02	1.10
PARTICIPATING IN A MATH-FOCUSED PROFESSIONAL DEVELOPMENT SESSION.	1.52	0.95	2.35	1.41
TOTAL INSTRUMENT	45.02	14.81	54.02	15.77

Appendix D – MTEBI MEANS AND STANDARD DEVIATIONS

1-Strongly Disagree. 2-Disagree 3-Neither Agree Nor Disagree 4-Agree. 5-Strongly Agree

	IN. (N=174)		PRE. (N=51)	
ITEM	Mean	S.D.	Mean	S.D.
WHEN A STUDENT DOES BETTER THAN USUAL IN MATHEMATICS, IT IS OFTEN BECAUSE THE TEACHER EXERTED A LITTLE EXTRA EFFORT.	3.53	0.98	3.71	0.90
I WILL CONTINUALLY FIND BETTER WAYS TO TEACH MATHEMATICS.	4.66	0.75	4.51	0.65
EVEN IF I TRY VERY HARD, I WILL NOT TEACH MATHEMATICS AS WELL AS I WILL MOST SUBJECTS.	4.30	1.06	3.29	1.32
WHEN THE MATHEMATICS GRADES OF STUDENTS IMPROVE, IT IS OFTEN DUE TO THEIR TEACHER HAVING FOUND A MORE EFFECTIVE TEACHING APPROACH.	4.13	0.70	4.22	0.73
I KNOW HOW TO TEACH MATHEMATICS CONCEPTS EFFECTIVELY	4.21	0.80	3.40	0.94
I AM NOT VERY EFFECTIVE IN MONITORING MATHEMATICS	3.90	1.14	3.76	1.05
IF STUDENTS ARE UNDERACHIEVING IN MATHEMATICS, IT IS MOST LIKELY DUE TO INEFFECTIVE MATHEMATICS TEACHING.	3.06	1.00	3.47	0.92
I GENERALLY TEACH MATHEMATICS INEFFECTIVELY.	4.46	0.83	4.10	0.92
THE INADEQUACY OF A STUDENT'S MATHEMATICS BACKGROUND CAN BE OVERCOME BY GOOD TEACHING.	3.94	0.93	4.12	0.79

WHEN A LOW-ACHIEVING CHILD PROGRESSES IN MATHEMATICS, IT IS USUALLY DUE TO EXTRA ATTENTION GIVEN BY THE TEACHER.	4.06	0.75	4.00	0.72
I UNDERSTAND MATHEMATICS CONCEPTS WELL ENOUGH TO BE EFFECTIVE IN TEACHING ELEMENTARY MATHEMATICS.	4.49	0.80	3.94	1.08
THE TEACHER IS GENERALLY RESPONSIBLE FOR THE ACHIEVEMENT OF STUDENTS IN MATHEMATICS.	3.79	0.84	3.71	0.86
STUDENTS' ACHIEVEMENT IN MATHEMATICS IS DIRECTLY RELATED TO THEIR TEACHER'S EFFECTIVENESS IN MATHEMATICS TEACHING.	3.78	0.85	3.80	0.92
IF PARENTS COMMENT THAT THEIR CHILD IS SHOWING MORE INTEREST IN MATHEMATICS AT SCHOOL, IT IS PROBABLY DUE TO THE PERFORMANCE OF THE CHILD'S TEACHER.	3.68	0.89	3.8-	0.90
I FIND IT DIFFICULT TO USE MANIPULATIVES TO EXPLAIN TO STUDENTS WHY MATHEMATICS WORKS.	4.27	1.02	3.71	1.20
I AM TYPICALLY ABLE TO ANSWER STUDENTS' QUESTIONS.	4.59	0.81	4.18	0.65
I WONDER IF I HAVE THE NECESSARY SKILLS TO TEACH MATHEMATICS.	4.20	1.03	2.69	1.41
GIVEN A CHOICE, I WOULD NOT INVITE THE PRINCIPAL TO EVALUATE MY MATHEMATICS TEACHING.	4.26	1.14	3.41	1.22

WHEN A STUDENT HAS DIFFICULTY UNDERSTANDING A MATHEMATICS CONCEPT, I AM USUALLY AT A LOSS AS TO HOW TO HELP THE STUDENT UNDERSTAND IT BETTER	4.24	0.95	3.67	1.01
WHEN TEACHING MATHEMATICS, I USUALLY WELCOME STUDENT QUESTIONS.	4.78	0.70	4.77	0.51
I DO NOT KNOW WHAT TO DO TO TURN STUDENTS ON TO MATHEMATICS.	3.94	1.02	3.18	1.13
TOTAL INSTRUMENT	86.23	9.79	79.41	10.43

BIOGRAPHY OF THE AUTHOR

Samuel Ward grew up in Hampden, Maine and graduated from Hampden Academy in 2013. After high school he enrolled at the University of Maine and earned a Bachelor of Arts in Mathematics. Sam continued his education at the University of Maine, enrolling in the Master of Science in Teaching program in the Spring of 2018. In the fall of 2019, Sam began working as a high school mathematics teacher at Traip Academy in Kittery, Maine. Sam is a candidate for the Master of Science in Teaching degree from the University of Maine in August 2020.