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Predictive Factors of Student Mathematics Achievement Decline Between Third and Fifth Grade

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Abstract

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EdS, Walden University, 2012

MA, Webster University, 2001

Research Study Submitted in Partial Fulfillment

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Abstract

Low math achievement among elementary school students is a concern because students who lack a strong early foundation in mathematics may experience difficulty learning in future mathematics classes. Students in 2 rural southeastern school districts demonstrated low math achievement in 5th grade and their scores declined from 3rd to 5th grade. In this quantitative study, teacher-related factors that research has shown to predict student achievement were examined using Bandura's theory of self-efficacy and Ball and McDiarmid's emerging theory of subject matter content knowledge. The research question asked whether the teacher factors, years of teaching experience, hours of professional development in math pedagogy, college math courses completed, math teacher preparation courses, and teaching efficacy, predicted student math achievement in the 2 districts. Data were collected from 29 3rd grade teachers and 32 5th grade teachers and analyzed using binary logistic regression. The findings showed that the combination of predictors did not significantly predict math achievement of 5th grade students. However, teachers who had 1 to 9 years of teaching experience were more likely to have students with higher math achievement than those with more than 20 years of experience (OR = 4.96; p = .048). The inconclusive results indicate that additional factors that might influence students' math achievement have to be explored and additional professional development has to be offered, especially for teachers who have been teaching for 2 decades as they might have learned curriculum and pedagogy different from current practice. Positive social change will occur when all elementary teachers are able to facilitate students' learning of mathematics and the students successfully master math concepts.

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Dedication

First, all glory to God who has given me strength to endure the trials and live during this program. I would like to dedicate this work to my mother, Evelyn Roberts. I love you mom, may you rest in peace.

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I would first like to give honor to God who provided me with the perfect partner, my husband, who has been patient and supportive. The doctoral journey has been humbling and the demands have exposed both our weaknesses. We have been shown the meaning of patience, hope, and God's promises. For this, I must extend my thanks for this accomplishment and acknowledge the people who were intentionally placed in positions to help me achieve what I did not think was possible.

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Section 1: Introduction to the Study

Introduction

Due to growing concerns about mathematics achievement among students in the United States, more attention has been placed on teacher knowledge of math content and pedagogy. To prepare students for success in the 21st century, Pasquinelli (2011) argued that teachers should possess the necessary knowledge and skills to instruct students in science and technology and, thus, prepare them to compete in the global market. Furthermore, given that success in technology and science depends heavily on mathematics (Wagner, 2008), teachers need significant math knowledge and skills in order to instruct students in math beyond a basic level. Exactly what should be done to improve math knowledge among teachers is debated, but researchers like Peterson, Barrows, and Gift (2016) have indicated that improving the math and reading skills of this generation of U.S. students is critical to their future success.

According to the National Council of Teachers of Mathematics (NCTM; 2015), teachers must instruct students in the core skills of critical thinking, reasoning, analyzing, and communicating mathematically. To successfully teach students advanced mathematics knowledge and skills, teachers must possess advanced math knowledge and pedagogical skills themselves (NCTM, 2015). Separate studies conducted by the National Council on Teacher Quality (NCTQ; Greenberg & Walsh, 2008) and Osborne (2015) found that many American elementary teachers were weak in mathematical skills and knowledge. To ensure that students receive a quality education in mathematics, schools must ensure that teachers are provided development opportunities in math (Akiba &

Liang, 2016; Chang, 2015). The NCTM argued that teachers will be required to instruct students at a higher mathematical level in the future; therefore, the U.S. teacher population will need in-service and preservice preparation in mathematics to be successful (Jong, 2016; NCTM, 2015; Pasquinelli, 2011; Schmidt, Cogan, & Houang, 2011; Wagner, 2008). According to the NCTM, quality preservice teacher preparation programs in mathematics should provide teachers with effective teaching methods that help them establish a strong math foundation in the early elementary student classroom. Just as the future of young learners depends on a foundation of mathematical experience built on understanding, explaining, and reasoning with math concepts, so too must teachers develop high-level math pedagogy skills that enable them to fully engage students of all ages and backgrounds in learning mathematics (NCTM, 2015).

Problem Statement

In 2011 and 2012, two rural school districts in the southeastern United States reported low math achievement among fifth-grade students and a clear decline in math achievement between the third and fifth grades. I will refer to these school districts as County School District 1 (CSD1) and County School District 2 (CSD2). Reports from the State Department of Public Instruction showed that 72% of third-grade students in CSD1 performed at grade level or above. By the time these same students reached the fifth grade, however, math achievement declined by 3.6%. In CSD2, 45.5% of third-grade students demonstrated low math performance compared to 47% of fifth-grade students, indicating a decline of 1.5% in math performance between third and fifth grades.

Students who do not develop math skills in the early stages of their learning are likely to lack the necessary skills that form the foundation for more advanced mathematics courses. This was confirmed by the National Assessment of Educational Progress (NAEP; 2017), which found that the percentage of students who achieved basic and below basic levels in mathematics increased as students progressed through the grades. In 2017, 60% of fourth-grade students nationwide, 66% of eighth-grade students nationwide, and 78% of 12th-grade students nationwide achieved at basic and below basic levels (National Center of Education Statistics, 2017).

I chose to study the relationship between factors associated with teacher mathematics knowledge and math achievement at the elementary level for two interrelated reasons: (a) low achievement in early education can lead to larger problems as students grow older, and (b) the math knowledge and skills of teachers themselves can impact student math achievement. The variables investigated in this study included various factors related to teacher knowledge of mathematics content and pedagogy (i.e., teaching experience, professional development, college math courses, teacher preparation courses, and teaching efficacy); student math achievement among third- and fifth-grade students; and the grade level taught in order to determine whether teacher math knowledge predicts a decline in student math achievement from third to fifth grade.

Nature of the Study

Using a quantitative prediction study, I explored whether factors related to teachers' knowledge of mathematics content and pedagogy (i.e., years of experience teaching mathematics, hours of professional development in math pedagogy, number of completed college-level math content courses, number of teacher preparation courses in mathematics instruction, and mathematics teaching efficacy) predict student mathematics achievement in third and fifth grades. I also explored to what extent these same factors predict grade level taught in an effort to explain the decline in mathematics achievement that occurs from third to fifth grade. I conducted this study in two rural school districts in the southeastern United States, CSD1 and CSD2, between 2017 and 2018 to addresss the following research questions and hypotheses:

Research Question 1: Do teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) significantly predict student math achievement in third and fifth grades?

$H_0 1$: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do not significantly predict student achievement in third and fifth grades.

$H_a 1$: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do significantly predict student math achievement in third and fifth grades.

Research Question 2: Do teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) predict grade level taught?

$H_0$2: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do not significantly predict grade level taught.

H_a2: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do significantly predict grade level taught.

Purpose of the Study

The purpose of this quantitative, prediction study was to understand and explain the math achievement decline that occurs between third and fifth grade at two school districts in the southeastern region of the United States. In this study, I strove to determine whether teacher factors (i.e., years of experience teaching mathematics, hours of professional development in math pedagogy, college-level math content courses completed, teacher preparation courses in mathematics instruction, and mathematics teaching efficacy) predict mathematics achievement of third- and fifth-grade students as well as how well these factors predict the grade level taught. The results of this study will help these school districts better understand the low math achievement among fifth-grade students and the decline in math achievement between third and fifth grades. The districts may use the study findings to address student math achievement and instruction and identify the support needed to improve teacher mathematics content knowledge and pedagogy.

Theoretical Framework

This study was grounded in two theories. First, was the emerging theory of subject matter content knowledge preparation of teachers (Ball & McDiarmid, 1989), which is based on the work of Shulman (1986). Ball and McDiarmid (1989) argued that subject matter content knowledge is a central component of teaching and that it is composed of three dimensions: (a) substantive knowledge of the subject, (b) substantive knowledge about the subject, and (c) dispositions toward the subject. Knowledge of the subject refers to knowledge of the substance of the subject, such as "ideas, facts, and theories of a subject" (Ball & McDiarmid, 1989, p. 8). Knowledge about the subject refers to knowledge of the nature of the subject, or "a host of understanding about the subject" (Ball & McDiarmid, 1989, p. 8), such as understanding the controversies in the field, current directions and applications of the field, and how discourse in the field is conducted. Dispositions toward the subject refers to "taste and distaste for particular topics and activities" (Ball & McDiarmid, 1989, p. 10) within a subject and how individuals perceive themselves as learners or participants in the subject.

In the theory, Ball and McDiarmid (1989) argued that knowledge is acquired from three sources: (a) precollege curriculum, (b) college curriculum, and (c) teaching experience. The precollege curriculum includes what teachers learn from elementary and secondary teachers, the school curriculum, their peers or tutors, or from their families (Ball & McDiarmid, 1989). The college curriculum includes what teachers learn from college arts and sciences courses and from preservice education courses, while teaching experience includes what teachers learn from teaching, from the textbooks used, and from the attitudes and expectations that their students bring to classroom learning (Ball & McDiarmid, 1989). Although not discussed by Ball and McDiarmid, it is likely that teachers also learn subject matter content knowledge from other teachers and from various types of professional development.

The second theory that grounded this study was that of self-efficacy. This is a theoretical component of social cognitive theory developed by Bandura (1997). According to Bandura's theory, self-efficacy in an educational setting refers to a teacher's confidence in their ability to achieve positive student outcomes.

Operational Definitions

Academic mathematics content knowledge: Knowledge of the subject, which refers to the substance of the subject, such as "ideas, facts, and theories of a subject" (Shulman, 1986, p. 8). In this study, content knowledge was measured by the number of mathematics content courses a teacher has completed at the university level.

Elementary mathematics specialists: "Elementary mathematics specialists are teachers, teacher leaders, or coaches who are responsible for supporting effective mathematics instruction and student learning at the classroom, school, district, or state levels" (Association of Mathematics Teacher Educators, 2013, p. 1).

Mathematics pedagogical knowledge: The teaching methods that teachers employ to instruct students in mathematics. In this study, pedagogical content knowledge is defined as knowledge of the nature of the subject, "a host of understanding about the subject" (Ball & McDiarmid, 1989, p. 9), which includes understanding the controversies in the field, current directions and applications of the field, and how discourse in the field is conducted. Mathematics pedagogical knowledge in this study was measured by the number of courses that teachers had completed in mathematics pedagogy and the number of hours of professional development that teachers had completed in mathematics pedagogy.

Professional development: "Professional development is the method by which teachers best acquire and develop knowledge needed to teach academic subjects" (Ball & McDiarmid, 1989, p. 17). In this study, professional development was measured by the number of hours of professional development the teachers had completed.

Standards-based teaching: Instruction and assessments that center on a set of focused targets or objectives in a program (NCTM, 2015).

Teaching efficacy: A teacher's confidence, within an educational setting, in their ability to achieve positive student outcomes (Bandura, 1997). In this study, teaching efficacy was measured by the Mathematics Teaching Efficacy Belief Instrument (MTEBI), which produces a teaching self-efficacy scale score and an outcome efficacy scale score.

Teaching experience: The number of years a teacher has been teaching (Darling-Hammond, 2009). In this study, teaching experience was measured as the total number of years teaching.

Assumption, Limitations, Scope, and Delimitations

Assumptions

While conducting this research, I made assumptions about the study participants and their participation in the study. I assumed that all teachers assigned in the third and fifth grades were interested in supporting this research. I also assumed that potential participants would demonstrate their support by participating in the study and responding to the survey (MTEBI) and the demographic questions truthfully.

Limitations

The primary limitation of this study was the small sample size. Due to the local nature of this study and the small sample size, the generalizability of the findings is limited. With this limitation in mind, I did not attempt to generalize the study results beyond the two school districts under investigation and the population of third- and fifth-grade teachers. I acknowledge that the teachers who consented to participate may not have represented the general population of all mathematics teachers in CSD1 and CSD2. Consumers of this research should use caution when considering the results beyond the scope of the study.

Scope and Delimitations

The scope of this study was third- and fifth-grade teachers at elementary schools in two school districts in the southeastern United States. The study was delimitated to student mathematics achievement and the decline in mathematics achievement between third- and fifth-grade students. The study was not intended to explore the relationship between teacher demographic information and student mathematics achievement. This study was also not intended to determine cause and effect or to determine the relationship of teaching practices with student achievement.

Significance of the Study

According to the State Department of Public Instruction, the low mathematics achievement of students in the CSD1 and CSD2 is a concern among district leadership and stakeholders. With this study, I addressed the issue of low mathematics achievement in the fifth grade and the decline in math achievement between third and fifth grade. The study findings may add to the body of knowledge about teacher factors that predict mathematics achievement of fifth-grade students and may increase understanding about the decline in math achievement between the third and fifth grades.

Success in mathematics requires that students have a strong mathematics foundation, a solid understanding of math concepts, and the ability to apply math to solve problems inside and outside of the classroom (Wagner, 2008). Given the importance of providing all students with high-level math skills and knowledge as well as the need to provide well-prepared mathematics teachers, the findings of this study will directly benefit CSD1 and CSD2. The results of this study may assist the districts in making informed decisions about professional development opportunities for teachers that will best increase their math content and pedagogical knowledge. At the local level, the findings of this study will contribute to positive social change by promoting better mathematics instruction through an increased understanding of the teacher factors that affect student achievement in mathematics.

Summary

Low student achievement in mathematics in fifth grade at CSD1 and CSD2 and the decline in mathematics achievement between third and fifth grades is concerning. Using a quantitative, prediction study, I investigated the relationship of teacher factors to determine whether these factors predicted fifth grade math achievement at CSD1 and CSD2, two school districts in the southeastern United States. In an effort to explain the decline, I also explored the teacher factors and the third- and fifth-grade students' math scores to determine whether the teachers' grade level taught could explain the mathematics achievement decline that occurs from third to fifth grade in CSD1 and CSD2. The findings may better inform these school districts about the relationship between teacher factors and student math achievement so that they can best support teacher and student achievement in high-level mathematics.

In Section 2, I will review the literature on teacher factors (i.e., years of experience teaching mathematics, hours of professional development in math pedagogy, college-level math content course completions, number of teacher preparation courses in mathematics instruction, and math teaching efficacy) that are known to influence student achievement. In Section 3, I will describe and justify the research design and approach of this study. I will also describe the sample and setting, research instrumentation and materials, data collection and analysis, protection of the participants, and role of the researcher. In Section 4, I will present and discuss the findings of this study. In Section 5, I will interpret the research findings and provide recommendations for future research and actions.

Section 2: Literature Review

Introduction

In this study, I explored the extent to which teacher-related factors predict the low mathematics achievement of fifth-grade students and the math achievement decline between third and fifth grade in two school districts (i.e., CSD1 and CSD2). To design this study and investigate the decline of student mathematics achievement, I conducted an extensive review of the literature on teacher-related factors that affect student math achievement. Specifically, I examined the literature that explored these specific factors: (a) years of teaching experience, (b) professional development hours in math pedagogy, (c) college-level math content courses completed, (d) teacher preparation courses in math instruction, and (e) mathematics teaching efficacy.

To locate the relevant literature, I searched multiple databases, including Academic Search Premier, ERIC, ProQuest Dissertations, and those accessible through the Walden University Library. Some of the key words and phrases that I used to locate research articles and professional literature for this study were: *mathematics decline in the United States*, *low student mathematics achievement in elementary education*, *teacher factors and low mathematics*, *teacher efficacy and mathematics achievement*, *teacher experience and mathematics achievement*, *professional development and teacher education*, *teacher preparation and mathematics achievement*, *content pedagogy and mathematics achievement*, *in-service and pre-service mathematics content knowledge*, and *mathematics achievement.* I concluded the search when repeated use of the search terms, individually and in combination, resulted in no new references. I also reviewed many related research articles from peer-reviewed professional journals, websites, and books authored by recognized experts to ensure that I had saturated the literature on teacher-related factors and student math achievement. The literature review was developed using teacher factors as key ideas that impact student math achievement.

Literature Review Related to Key Variables and Concepts

The Effect of Teacher Experience on Student Mathematics Achievement

Student achievement in math can often depend on how well a teacher understands mathematics and is able to deliver math instruction in the classroom environment. Researchers have found that teacher experience in mathematics instruction leads to a more effective mathematics teaching practice, which relates to student math achievement (Ball, Hill, & Bass, 2005; Darling-Hammond, 2009; Stronge,Ward, & Grant, 2011). Teacher experience has a considerable effect on student math achievement because the longer a teacher has taught, the more effective that teacher should be (Ball et al., 2005; Darling-Hammond, 2009; Konstantopoulos & Chung, 2011).

Experienced teachers are thought to be more effective; however, researchers have found that the impact of teacher experience on student achievement can vary (Ball et al., 2008; Darling-Hammond, 2009; Stronge et al., 2011). Stronge et al. (2011) conducted a two-phase study on teacher effectiveness to determine whether teacher experience significantly correlated with student achievement in math and reading. The researchers measured teacher effectiveness through scores on tests administered to students in math and reading at the beginning and end of the school year. The gains in student achievement were determined by comparing student scores between the two tests, and student scores were matched with the teachers who administered the end of the year test (Stronge et al., 2011). In Phase 1 of the study, Stronge et al. compared teachers who had 10 years of service with teachers who had less than 10 years of service using a hierarchal linear model to determine how student achievement was affected by the following factors: years of teaching, gender, ethnicity, type of degree, and post master's coursework. However, there was no significant relationship between teacher experience and student success when measured this way (Stronge et al., 2011). In Phase 2, Stronge et al. investigated the relationship between effective teaching and teacher experience, classroom management, pedagogical methods, and content knowledge using an in-depth cross-case analysis of the teachers' instructional and classroom management practices. The researchers found that when teaching experience and other associated qualities of the effective teacher (i.e., classroom management, positive relationships, and pedagogical methods) were considered as a whole, there was a significant relationship between teacher experience and student math achievement.

The results of Stronge et al.'s (2011) study indicated that years of teaching experience alone did not significantly influence student achievement; instead, the researchers found that experienced teachers had acquired behaviors and characteristics that were associated with teacher effectiveness and this positively influenced student achievement. The differences identified between experienced and inexperienced teachers were in their classroom management, positive relationships, and pedagogical methods, which experienced teachers gained from having spent more years teaching; these characteristics positively affected the classroom learning environment and student achievement in mathematics (Stronge et al., 2011). Stronge et al. recommended that further research be conducted to explore the complexity of classroom teaching and further explain how experienced teachers enhance student achievement.

The Effect of Professional Development in Math Pedagogy on Student Math Achievement

PD in math pedagogy can improve teacher math instruction by providing teachers with needed training and support for teaching math content. Such PD for teachers is intended to update teacher knowledge and strengthen teacher pedagogical skills with the goal of increasing student achievement (Kutaka et al., 2017). Pedagogy skills gained from PD can increase a teacher's math knowledge and instructional tools, improving teachers' ability to make math knowledge accessible to their students and improve student math achievement (Kutaka et al., 2017). According to Darling-Hammond (2009), schools that provide PD support to their teaching staff promote teacher effectiveness and student achievement by increasing their teachers' pedagogy skills and subject mastery.

An early study by Hill (2007) examined the relationship between two types of continuing education PD and graduate degree courses by using data from the 2001 NCES Professional Development Survey, which had been completed and collected from 108,000 student teachers in the United States who received degrees in education. Hill found that 99% of teachers reported that they learned more when they participated in PD that was aligned with the standards and curriculum used in their daily practice. The survey results also indicated that teaching effectiveness increased when the PD was content-focused, used curriculum materials, and was linked to the teaching methods for the subject matter (Hill, 2007). The results also showed that PD in mathematics unequivocally increased student achievement in mathematics when the PD was long term and focused on a shared vision (Hill, 2007).

Other researchers (i.e., Faulkner & Cain, 2013; Jacobs, Koellner, & Funderburk, 2012; Koellner, Jacobs, & Borko, 2011) have found that ongoing PD focused on math content can provide teachers with opportunities to learn and implement what they have learned to increase student math achievement. Faulkner and Cain (2013) used a site-based PD that promoted teacher math learning. The math knowledge that teachers gained from the PD in the study improved the depth of their math knowledge, which improved their math practice and resulted in increased student math achievement. Based on their findings, Faulkner and Cain argued that the PD opportunities should be content focused, directly related to math teaching, and specifically address teacher weaknesses in mathematics. They asserted that PD for mathematics teachers should focus on particular math content areas or topics that will deepen the teachers' mathematical understanding (Faulkner & Cain, 2013). For example, if a teacher's weakness is problem solving, targeted PD could focus on providing teachers with problem-solving strategies to teach to their students.

In the same study, Faulkner and Cain (2013) investigated the effectiveness of PD in mathematics for elementary (K–12) teachers to test whether PD could improve the mathematics performance of students in both general education and special education. To investigate the effectiveness of PD, Faulkner and Cain measured a 40-hour PD that used the North Carolina foundations of mathematics training (NCFMT), which was specifically designed to improve the teachers' number sense. The treatment group of teachers in their study received district-wide training and included both general-education and special-education teachers in K–12. For comparison, a second group of teachers in their study (Group A) received state training in grade level mathematics and NCFMT training, and a third group (Group B) did not receive district, state, or NCFMT mathematics training. Both the treatment group and comparison roup A showed increased performance in their study; however, Group B showed a slight decline in performance. Their findings indicated that PD positively impacts teacher content knowledge.

This type of PD for teachers can also be provided through the structure of professional learning communities (DuFour, DuFour, & Eaker, 2008; Koellner et al., 2011). Koellner et al. (2011) explored the effect of math teacher participation in a professional learning community on the development of their math content knowledge. Koellner et al. used a small-group workshop that focused on building teacher math capacity by developing their leadership skills. The researchers argued that to improve math achievement, PD should prepare teachers to be subject leaders that can implement high-quality math instruction and act as guides to support the needs and interests of fellow math teachers (Koellner et al., 2011). In doing so, the PD would take on the features of a math professional learning community that would develop the teachers' knowledge of mathematical instruction and remain adaptable to teachers' needs (Koellner et al., 2011). Koellner et al. argued that effective PD programs that take the form of professional learning communities can provide teachers with the skills needed to improve their mathematics instruction and lead to higher student math achievement.

In their study, Koellner et al. (2011) facilitated a PD workshop for middle-school leaders in an urban school district that was designed to help teachers implement a Problem-Solving Cycle of Professional Development (IPSC). The problem-solving cycles were a long-term approach to mathematics PD that were conducted over 3 school years, including teacher leaders and mathematics teachers from eight middle schools (Koellner et al., 2011). Koellner et al. collected qualitative and quantitative data through interviews, scores from the administration of the Mathematical Knowledge for Teachers of Middle School, and video recordings of all instruction support meetings. The results from the Mathematical Knowledge for Teachers of Middle School showed that participants achieved significant gains in math teaching knowledge. Among the participating teachers, the IPSC development workshops fostered a community that was maintained in their group work and observed in the workshop videos. For example, teachers in the study were able to brainstorm, come up with strategies, make suggestions, and collaborate on math tasks to help each other gain a deeper understanding of the math content. Koellner et al. found that teacher leaders who implemented the problem-solving workshop model in their PD increased other teachers' knowledge of math over time.

Jacobs et al. (2012) adopted the IPSC that was designed by Koellner et al. (2011) to improve math teaching practices and professional learning in a large urban district with 50,000 students in 11 middle schools. Stakeholders in this district were interested in sustainable PD that could empower their teachers and students in math (Jacobs et al. (2012). Although the IPSC development was a 3-year program, Jacobs et al. saw an improvement in teacher and student achievement in the second year, which was evident in higher student test scores and a change in the standard curve equivalency scores that revealed every class had a 1-year increase in student mathematics learning. Jacobs et al. found that a PD that used problem-solving cycles was effective and that IPSC had a significant impact on teachers' math content knowledge.

Multiple studies (Faulkner & Cain, 2013; Jacobs et al., 2012; Koellner et al., 2011) about PD for mathematics teachers have indicated that effective PD should (a) increase a teacher's content knowledge and pedagogy skills, (b) improve a teacher's practice, and (c) improve student achievement. Effective mathematics PD must have consistent long-term support from the professional learning community that allows teachers to gain an in-depth knowledge of math problem solving and to construct individual math lessons that reflect the needs of their students (Faulkner & Cain, 2013; Jacobs et al., 2012; Koellner et al., 2011). Teachers that participate in effective math PD not only increase their content knowledge and pedagogy skills but also improve their capacity to teach math content and increase student math achievement (Koellner et al., 2011).

The Effect of Teacher College-Level Math Courses on Student Math Achievement

Taking advanced math coursework can have a positive effect on a teacher's instructional practice that may impact student math achievement. Math teachers must have an expertise in the subject that enables them to meet the rigorous math Common Core Standards. To achieve this, Schmidt et al. (2011) recommended the need for a balance in math content coursework and pedagogy for math teachers during their preservice education. Teachers' math content knowledge must be grounded in math fundamentals, including algebraic and geometric thinking, numeration, base ten, and measurement and data (Ball et al., 2005). Coursework in math pedagogy content prepares teachers to respond appropriately to student challenges when they are learning math content in a classroom environment (Kleickmann et al., 2013). Depth of content and pedagogical knowledge effectively prepares teachers to teach mathematics so that they understand both how students learn math as well as how to teach math to students effectively to increase student math achievement (Ball et al., 2005).

Quality mathematics instruction is related to the content knowledge of the teacher (Ball et al., 2005). Studies by the NCES (2008) and the NCTM (2014) found a positive relationship between teacher content knowledge and student achievement in math and science. According to Ball et al. (2005), increased teacher math content knowledge improved the quality of mathematics teaching. Teachers must be competent in the mathematics that they teach in the classroom to be effective; the content knowledge needed by elementary level math teachers is therefore different from the math content knowledge required in other occupations such as engineering, physics, accounting, and carpentry. Teachers must have a conceptual understanding of math, including knowledge of how to develop their students' procedural skills and how to teach problem-solving strategies.

Various researchers (Ball et al., 2005; Hill, Rowan, & Ball, 2005; Moreira & David, 2008) have found that much of the math that teachers learned in their own elementary and high school math classes does not meet the level of in-depth knowledge required for teaching in the modern math classroom. Ball et al. (2005) closely examined the mathematical knowledge and skills needed by elementary math teachers to test the hypothesis that math teachers require specialized math knowledge that differs from other professions that use math. They found that teacher math knowledge positively predicted gains in student math achievement and that the knowledge required for elementary-level math teachers was specific to numbers and operations, patterns, functions, algebra, and geometry (Ball et al., 2005). These topics were composed of two key elements: (a) common knowledge of mathematics that any adult would know, and (b) mathematical knowledge specific to teaching math. Ball et al. explained that teacher-specific math knowledge included math reasoning and communication, and fluency in mathematical terminology because math teachers must be fluent in math terms, reasoning, and communication in order to provide students with examples and visual representations critical to effective math teaching.

Marshall and Sorto (2012) found a similar pattern to Ball et al. (2005) in the common and specialized math knowledge that teachers should possess in their analysis of the effect of teacher math content knowledge on student achievement using longitudinal data collected from 55 rural Guatemalan primary schools from 2001 to 2002. In this study, approximately 900 students at the primary and middle-school levels took mathematics assessments and 90 teacher participants completed questionnaires that measured their teaching experience and math content knowledge (Marshall & Sorto, 2012). The teachers also participated in several math activities designed to measure their specialized content knowledge in primary mathematics teaching. Like Ball et al., Marshall and Sorto found that effective math teachers have two kinds of mathematical knowledge: common and specialized. Teachers demonstrated common math content knowledge and more specialized content when teaching multiplication, division, decimals, and fractions, which required explanations and mathematical reasoning unique to math pedagogy. The most significant predictor of teacher mathematical knowledge was the measure that combined both common and specialized content knowledge, leading Marshall and Sorto to argue that effective math teachers need both types of knowledge to improve student achievement. Marshall and Sorto also suggested that teachers with higher levels of math knowledge will have an increased knowledge of both math content and specialized content that will make them more effective in the classroom. They recommended that future research should build on these results and adopt a comprehensive protocol for observing and measuring teacher pedagogical math practices in the classroom (Marshall & Sorto, 2012).

The emergence of the Common Core Math require that rigorous math content be taught starting in the early learning classroom. The NCTM (2015) and National Association for the Education of Young Children (2010) separately confirmed that mathematics education should be challenging and accessible for children from 3–6 years old. Early childhood classrooms are vital for building the foundations of future mathematics learning through research-based curriculum and teaching practices.

Claessens, Engel, and Curran (2014) examined the relationship between academic content coverage in kindergarten and student achievement using a nationwide data set. The researchers used the Early Childhood Longitudinal Study-Kindergarten Cohort to investigate how math and reading content exposure related to student achievement in these areas at the kindergarten level. Claessens et al. found that content exposure, particularly in mathematics, led to larger cross-kindergarten score gains; students who had attended preschool benefitted from content exposure. These results demonstrated that teachers who provide students with advanced content coverage in early-learning classrooms are vital for student success in mathematics.

National policy, state colleges, and certification programs all recommend that teachers' coursework and content knowledge align with the mathematics teaching guidelines (Harrell & Eddy, 2012). According to Harrell and Eddy (2012), these recommendations are designed to improve teachers' content knowledge in mathematics so they are prepared to teach math to their students. If policies and standards for mathematics teachers are acted upon, the results will lead to more student success in mathematics and an increased ability for these students to compete in the global market (Harrell & Eddy, 2012). However, some studies on the impact of teachers' college math courses do not show a positive relationship with student achievement (Badgett, Decman, & Carman, 2013; Goldhaber, Liddle, & Theobald, 2013; Hill, 2007). The mixed results regarding the effect of teachers' graduate-level degrees and course content on their student achievement has led some scholars to question whether degrees received after teacher certification actually impact student math achievement (Badgett et al., 2013; Hill, 2007). These inquiries question whether courses taken to improve a teacher's content knowledge are sufficient to improve student achievement.

According to Hill (2007), improving student mathematics achievement is dependent on the math knowledge of the teacher. Furthermore, teachers who receive graduate math courses should participate in coursework that is related to what they teach in order to provide more advanced mathematics knowledge than their curriculum requires (Hill, 2007). However, because there are many different graduate programs available to teachers, Badgett, et al., (2013) were unable to establish a definite link between a teacher's higher education and student achievement. To test whether teacher education level contributed to student math achievement, Badgett et al. (2013) used the Texas Assessment of Skills and Knowledge Math tests, which are end-of-year student achievement tests in Texas. The researchers collected data from 1,026 teachers and conducted an analysis using a hierarchal regression model to test their hypothesis that teachers who obtained a master's degree would contribute to significant and positive change in student math achievement (Badgett et al., 2013). However, they were unable to confirm their hypothesis that teachers who obtained a graduate degree of any type contributed significantly to the math achievement of their students (Badgett et al., 2013). Instead, they found that teachers with graduate degrees had limited positive impact on student math achievement. Badgett et al. argued that because of the variety of educational programs available to teachers, many teachers achieved advanced degrees in areas that did not enhance their teaching positions or add to their instruction and student achievement. In fact, the results of Badgett et al.were consistent with other research that had found a questionable effect of teachers' graduate degrees on student math achievement (Hightower et al., 2011; Hill, 2007). Badgett et al. concluded that further research is needed on the contribution of subject-specific teacher graduate degrees on student achievement.

Hill (2007) sought to clarify the type of continuing teacher education that would positively affect student achievement. To accomplish this, Hill investigated two forms of continuing teacher education, graduate degrees and PD, to determine which of the two best increased the content knowledge of teachers in math and impacted student achievement. Using data from the PD surveys administered by the NCES (2001), Hill analyzed surveys from 108,000 student teachers in the United States who received degrees in education. In the surveys, teachers reported the extent of their continuing education, including additional university courses, graduate degrees, and PD. Regardless of a teacher's motivation for pursuing a graduate degree, Hill found that there was a positive relationship between PD and student achievement. Hill also found that teachers with graduate degrees improved student achievement if their degree was related to content that they taught. Hill stated that teachers with master's degrees in mathematics positively influenced student math achievement and contributed significantly to the growth of their students in the subject matter. Hill suggested that further research on the study of graduate degrees for elementary educators is necessary because elementary teachers are responsible for teaching all subjects. Graduate coursework, advanced degrees, and additional math content education received by teachers should align with their teaching assignment in order to expand their content knowledge (Goldhaber & Brewer, 2000; Hill, 2007; Schmidt et al., 2011).

The Effect of Teacher Preparation Courses in Mathematics Instruction on Student Achievement

Teaching preparation programs play a significant role in readying teachers for the challenge of providing quality education to their students. The education that a prospective teacher gains prior to entering the profession is essential because it affects teacher practice and student success (Kalder & Lesik, 2011). Various researchers (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2009; Darling-Hammond, 2009, 2010; Kalder & Lesik, 2011) have argued that effective teacher preservice education programs are essential for providing prospective teachers with both pedagogical and content knowledge for teaching.

Boyd et al., (2009) studied various types of teacher preparation programs and their effect on teaching efficacy among math and English teachers. Using a New York City survey of all first- and second-year teachers from 2005, Boyd et al. identified 31 teacher preparation programs. The researchers studied graduates of these programs by measuring their students' standardized test scores after the teachers' first year of teaching. Boyd et al. researched each of the preparation programs by interviewing program directors, field experience directors, and other administrative staff and reviewing printed information about the programs. From this data, the researchers identified specific characteristics of the teacher education programs and linked these characteristics to the effectiveness of first-year teachers as measured by student standardized test scores in mathematics and reading. Boyd et al. found that the effect of teacher education programs on teachers varied, but they were unable to identify which program characteristics drove these trends. Ultimately, the researchers concluded that programs which provided practical teaching experiences positively related to teacher effectiveness in math and reading among the first- and second-year teachers but cautioned against interpreting the results too closely (Boyd et al., 2009).

Further investigating the impact of teacher preparation program quality on student achievement and teacher preparation, Goldhaber et al., (2013) conducted a study in the state of Washington. Goldhaber et al. used a two-stage model to study whether differences between teacher preparation programs affected student achievement on state math and reading tests differently. Using a sample of 8,718 novice and experienced teachers and 291,422 students, Goldhaber et al. collected data from five administrative databases prepared by Washington's Office of the Superintendent of Public Instruction The researchers also collected data on the preservice teachers' Washington Educator Skills Test Version B (WEST-B) results. The WEST-B is a basic skills and knowledge test administered to all preservice teachers, teacher candidates, and out-of-state teachers seeking a Washington state teaching certificate and is designed to reflect the knowledge and skills described in textbooks, the Washington Essential Academic Learning Requirement in curriculum guides, and certification standards documents. Goldhaber et al. used a regression model to determine whether preservice teacher education in Washington led to increased student achievement using data from the 2005–2006 and 2009–2010 third- and sixth-grade standardized test scores in both math and reading. They found no difference between teachers who were trained in Washington and those who were trained out of state. However, they did find that teachers who scored higher on the preservice assessment WEST-B were more effective math teachers and their respective teacher training programs were positively related to teacher experience (Goldhaber et al., 2013).

Teacher preparation programs may vary, but they are crucial for equipping teachers with the skills needed to be effective math instructors. Goldhaber et al. (2013) found that teacher programs vary by state and each program prepares teachers to meet certification requirements for that state. The variation in teacher preparation programs was also identified by Boyd et al. (2009). Differences in the targeted skills learned by teachers in these programs are evident in student achievement levels and are relevant for understanding the importance of teacher preparation on student math achievement.

Teacher preparation programs and mathematics courses impact preservice teacher math content knowledge. The NCTM (2014) stated that teacher education programs should align their math preparation programs to meet the NCTM recommendations so that all teachers are prepared to teach mathematics. The NCTM recommended that elementary teachers must acquire a broad conceptual knowledge of the mathematics that they will teach, moving well beyond mere procedural understanding. The teacher preparation schools should insist that teachers meet high standards for admittance into their programs and demonstrate that their knowledge of mathematics is at a level that is equivalent to second-year algebra. The NCTM argued that elementary teacher candidates should demonstrate a deeper understanding of mathematics content before completing the teacher preparation program as a condition for earning a license. The preservice elementary teachers should be taught a mathematics content course that emphasizes numbers and operations, prior to entering the classroom and the courses should provide numerous opportunities for teachers to practice, with emphasis placed on the delivery of mathematics content. The mathematics training of the preservice teachers should be provided by qualified mathematics professionals because effective math training is critical to preservice teachers who will be expected improve the mathematics performance of their students.

The mathematics content knowledge acquired by preservice teachers in their preparation courses is critical to their math practice and classroom success (Danielson, 2007; Darling-Hammond; 2011). The NCTQ examined whether teacher education programs provided preservice teachers with adequate mathematics education in 2008 and 2014 (Greenberg & Walsh, 2008; Greenberg, Walsh, & McKee, 2014). In both years, the NCTQ examined 1,061 teacher programs in universities that prepared elementary, graduate elementary, and special education teachers. The NCTQ (Greenberg & Walsh, 2008; Greenberg et al., 2014) found that 20% of the teacher training programs did not teach the mathematics content recommended for elementary teachers who wish to confidently and competently teach math. Although preservice programs prepared teachers with the confidence to teach, the NCTQ (Greenberg & Walsh, 2008; Greenberg et al., 2014) found that 994 of the schools examined in 2014 did not provide the appropriate amount of coursework in algebra nor the required number of semester hours in math content (Greenberg et al., 2014) to achieve the level of skill required for preservice teachers entering the classroom. The NCTQ (Greenberg & Walsh, 2008; Greenberg et al.,

2014) indicated that teacher preparation programs were unable to provide teachers with the depth of math knowledge needed for all the grades included in their certification.

Effective preservice teacher education programs that meet the qualifications recommended by the NCTM, provide teachers with the required math content and pedagogical knowledge necessary for teaching (NCTQ, 2014). When preservice teacher preparation programs do not adequately prepare math teachers, student math achievement suffers (NCTQ, 2014).

Schmidt et al. (2011) used the information that previous researchers found from the Teacher Education and Development Study in Mathematics and the Future Teacher Survey to investigate teacher education programs for secondary, middle, and elementary levels. Schmidt et al. wanted to compare preservice math teacher programs in the United States with those in other countries that are known to outperform the United States in math on the Programme for International Student Assessment. The researchers found that the largest differences in teacher preparation courses between countries occurred among lower secondary math teachers in the top-achieving countries and U.S. preservice middle-school teachers (Schmidt et al., 2011). Teachers from the top-performing countries took 34 hours of coursework during their preservice program compared to 25 hours in the U.S. preservice teacher program (Schmidt et al., 2011). Moreover, teachers in top-performing countries took nine additional credits in math content courses, three of which were math pedagogy courses (Schmidt et al., 2011). The researchers concluded that U.S. teacher preparation programs do not prepare lower middle and secondary preservice teachers adequately in math content (Schmidt et al., 2011).

A teachers' knowledge of math content and pedagogy is highly associated with effective mathematics instruction (Norton, 2012). Various researchers (Claessens et al., 2014; Darling-Hammond, 2010; Kleickmann et al., 2013; Lee, 2010; Norton, 2012) found that knowledge of both content and pedagogy are essential qualities that affect teachers' instructional practices.

Norton (2012) examined the math knowledge of preservice teachers by testing them on what they learned in their high school math classes before they enrolled in college to determine if their math knowledge and pedagogical skills would predict their success in math. Norton studied 122 primary preservice teachers and used the results of the National Assessment Program Literacy and Numeracy tests to measure numeracy and pedagogical content knowledge (Norton, 2012). About two thirds of the preservice teachers had taken mathematics through grade 10 (Level 2) and continued to take math during their senior year in high school. Most had a mathematical understanding at the ninth-grade level (Level 1), but about one third of the preservice teachers exhibited higher levels of high-school math knowledge (Levels 3 and 4). Those with higher math knowledge were associated with higher scores on the pre- and posttest of the NAPLAN. However, Norton found no significant difference between test scores of Levels 1 and 2, or between Levels 3 and 4. The results revealed that teachers who studied calculus (Level 3) scored significantly better than those who were at Level 1, but not Level 2 (Norton, 2012). Level 4 scored significantly better than Levels 1 and 2, but not significantly better than Level 3. Norton demonstrated that some content and pedagogy knowledge could be acquired by preservice teachers through math courses in high school, but the content and pedagogy skills gained at the high school level are not adequate for teaching math in the modern classroom. Norton suggested that further research is necessary to study the relationship between content and pedagogical knowledge received during a teacher's high school math education.

Teachers with pedagogical and content knowledge skills can positively affect student math achievement, as Kleickman et al. (2013) and others have found. Kleickmann et al. highlighted how preservice teacher education programs impact the development of pedagogical knowledge and content knowledge, which affects math instruction and student achievement. The researchers argued that both pedagogical and content knowledge learning opportunities began when teachers were in preservice education and continued during their in-service training. Kleickmann et al. compared the pedagogical and content knowledge of four groups of mathematics teachers at different points in their teaching career in Germany using a cross-sectional comparison study of pre- and in-service mathematics teachers. Kleickmann et al. administered the *Kognitver Fahigkeistest* (cognitive ability test), a 23-item test, and a questionnaire to the teachers in the study, and then compared the results of four groups of math teachers. Group 1 consisted of first-year, first semester preservice teachers, Group 2 consisted of third-year student teachers in at least their fifth semester, Group 3 consisted of student teachers at the end of the induction phase, and Group 4 consisted of experienced teachers. The study found the largest differences in pedagogical and content knowledge between groups at the beginning and end of the initial teacher education program, suggesting that there were structural differences within the preservice programs. For example, the first phase of teacher education is important in the development of content knowledge, but there were differences in the content knowledge of preservice teachers in the college-bound versus vocational track at the beginning of their university studies. The teachers who attended a preservice program in the academic track were offered intensive math courses, while teachers who attended the preservice program for the vocational track completed more general pedagogy coursework. These differences in the preservice programs affected the teachers' learning opportunities and this was reflected in their content and pedagogical knowledge (Kleickmann et al., 2013). The findings of the Kleickmann et al. (2013) study were similar to those of other studies on the content and pedagogical knowledge of preservice teachers (Boyd et al., 2009; Darling-Hammond, 2009; Hill, 2005; Norton, 2012; Schmidt et al., 2011). Other researchers (Ball et al., 2005; Kleickmann et al., 2013; Moreira & David, 2008; Norton, 2012; Schmidt et al., 2011) demonstrated that teachers must have more than a basic knowledge of mathematics content and pedagogy to improve student mathematical achievement.

The importance of mathematics content and pedagogy knowledge for in-service teachers. Mathematics pedagogy is the practice that teachers use to help their students understand math (Figueiredo, Gomes, & Rodrigues, 2018). Teachers who use effective pedagogical techniques provide opportunities for all students to learn (Danielson, 2007; Riese, Vogelsang, & Reinhold, 2012). By connecting mathematical ideas to their students' personal experiences, teachers with strong mathematics pedagogy skills can help students relate to math and discover how to use mathematics (Ball et al., 2005).

Lee (2010) assessed pedagogical content knowledge of kindergarten teachers using the Survey of Pedagogical Content Knowledge in Early Childhood Mathematics. Lee argued that the early mathematics skills are closely associated with a student's later math achievement, so the lack of pedagogical and math skills among early childhood teachers can disadvantage future math learning. Teacher pedagogical content knowledge was measured in six areas: number sense, pattern, ordering, shapes, spatial sense, and comparison. Lee found that kindergarten teachers were best at number sense and worst in spatial sense, kindergarten teachers who had doctoral degrees scored higher than teachers with either bachelor's or master's degrees, and teachers with more than ten years of experience had higher pedagogical content knowledge. The study also found that years of teaching experience and mathematics degrees were significantly correlated with teacher pedagogical content knowledge. Lee concluded that the lack of pedagogical content knowledge and essential math skills among early educators could negatively affect math learning experiences of early childhood learners.

The Effect of Self-Efficacy and Mathematics Teaching Efficacy on Student Mathematics Achievement

Teacher self-efficacy is the belief that one can significantly contribute to student academic success and positively affect student learning. Teacher self-efficacy is demonstrated by teachers in the classroom setting and can be observed in teacher–student relationships, teacher confidence, and instruction delivery (Throndsen & Turmo, 2013). According to Throndsen and Turmo (2013), teacher self-efficacy is future-oriented and reflected in the specific tasks and goals that teachers set for themselves and the effort that they invest in reaching those goals despite challenges. Teachers with self-efficacy believe that they can be successful in their teaching practice and influence their students to achieve high levels of performance.

Throndsen and Turmo (2013) used the goal orientation theory to examine the relationship between classroom environment and student math achievement in mathematics by examining the several constructs, the mastery goal structure for students, performance, approaches to instruction, and personal teaching efficacy. They studied 521 Norwegian primary mathematics teachers in second and third grades and their 9,980 students, administering the Patterns of Adaptive Learning Scales questionnaire to the teachers and a math diagnostic test to the students to measure their basic mathematics basic numerical, operations, and computation skills. The researchers found a strong positive relationship between instructional practice, performance approaches to instruction, and performance goal structure for students. Mastery goal structure for students and mastery approaches to education were also strongly related and correlated strongly with personal teaching efficacy.

Bates, Latham, and Kim (2011) studied the relationship between the self-efficacy of early childhood preservice math teachers and positive math outcomes of their students among 89 childhood preservice teachers from a large teacher preparation institution known for preparing teachers with certifications from pre-kindergarten to third grade. The researchers collected data using the Mathematics Self-Efficacy Scale, Mathematics Teaching Efficacy Beliefs Instrument, and the Illinois Certification Testing System Basic Skills Test (Bates et al., 2011). They found that preservice teacher self-efficacy positively correlated with the teachers' personal mathematics teaching efficacy. Preservice teachers who had higher mathematics self-efficacy demonstrated higher capability in teaching mathematics which positively affected their students' math achievement.

Teachers' beliefs affect their instructional practice and can affect the way their students learn math and achieve learning outcomes. Polly et al. (2013) studied the effects of math teachers' beliefs, instructional practices, and beliefs about instructional practices on student learning outcomes in mathematics. Survey data was collected from two school districts with the questionnaire Designing and Using Research Instruments to Describe the Beliefs and Practices of Mathematics Teachers, developed by Swan (2007). The questionnaire investigates teachers' beliefs about mathematics teaching and student learning outcomes to examine their self-reports about instructional practices. All study participants also completed the Mathematical Knowledge for Teaching Assessment to test teacher content knowledge. Student achievement scores were obtained from end-of-unit assessments in the Investigations in number, data, and space elementary curriculum developed by the Technical Education Resource Center in 2008. Polly et al. found that teachers' beliefs significantly affected math teaching practices. They found that teachers who used student-centered practice to teach mathematics made larger gains in math. They also found a significant relationship between teacher practices, beliefs in mathematics, and student outcomes. Polly et al. concluded that further research was needed to fully understand how teachers' beliefs about mathematics instruction can impact student math outcomes.

Research has indicated that there is an association between a teacher's beliefs and the type of teaching practices he or she uses (Bates et al., 2011; Polly et al., 2013; Throndsen & Turmo, 2013). This relationship can positively affect students' math achievement when teachers have confidence in their ability to teach the math curriculum and content to students. On the other hand, teachers without confidence in their ability to teach mathematics to students could have beliefs that negatively affect their practice, which could in turn significantly affect the student learning and performance on math standardized curriculum tests.

Mathematics teaching efficacy is defined as a teacher's beliefs regarding his or her ability to teach others math. Mathematics teaching efficacy allows a teacher to see him or herself as able to teach mathematics and help students improve their math achievement (Enochs, Smith, & Huinker, 2000). A teacher's beliefs about mathematics also influence their instructional practice. According to Mapolelo and Akinsola (2015), teachers who have had negative experiences with math during their education may not be able to teach math effectively. A teacher's negative experiences with mathematics, or math anxiety, can influence their math self-efficacy. In turn, these teachers can have doubts about their own ability to teach mathematics, with negative impacts on how these teachers carry out lesson their lessons (Beswick, 2012).

Gresham (2009) asked whether a relationship existed between elementary preservice teachers' mathematics anxiety and mathematics teacher self-efficacy, collecting data from 156 preservice teachers who were enrolled in a preservice mathematics methods course. Teachers were interviewed and then assessed with the

MTEBI and scored on the Mathematics Anxiety Rating Scale The analysis showed that preservice teachers with negative attitudes towards math had the highest levels of math anxiety and there was a moderate negative relationship between mathematics anxiety and mathematics teacher efficacy among preservice teachers. The interview data showed that preservice teachers with high levels of math anxiety had negative attitudes towards mathematics (Gresham, 2009). Teacher math anxiety also affected their teaching practices, descriptions and understandings of mathematics, and efficacy and belief in their ability to improve student math learning (Gresham, 2009). The survey data showed that teachers who were highly efficacious had low math anxiety and teachers with low self-efficacy had high math anxiety. Gresham concluded that teacher programs should make preservice teachers aware of their math anxiety to limit its negative impact on their preservice math coursework and improve their self-efficacy.

Another study by Briley (2012) explored the relationship between teachers' mathematics beliefs, teaching efficacy, and self-efficacy. The researcher asked 95 elementary preservice teachers enrolled in a mathematics content course for elementary school teachers to complete three surveys that measured their mathematics teaching efficacy, mathematics self-efficacy, and mathematical teaching beliefs, capabilities, or effectiveness. Briley found that preservice teachers who possessed stronger belief in their ability to teach mathematics effectively or those who had higher self-efficacy levels were more likely to have stronger positive feelings about their ability to teach math. Teachers with high self-efficacy were also more likely to be more confident when solving math problems (Briley, 2012).

Experienced teachers who have confidence and positive attitudes about math teaching believe they can positively change the way students view math and improve student math achievement (Putman, 2012). According to Putman (2012), teaching efficacy is an important factor in a teacher's practice. The constructs of teacher efficacy and a teacher's years of experience directly influence their self-efficacy (Putman, 2012). To investigate teacher efficacy, Putman studied three groups of teachers with differing levels of experience: preservice teachers, novice teachers with less than three years of experience, and experienced teachers with three or more years of experience. The teachers' self-efficacy was measured using the Teachers' Sense of Efficacy Scale The study findings showed that experienced teachers had high levels of general teaching efficacy, high levels of student engagement, and well-managed classrooms according to the scores. Putman explained, "the beliefs of the teacher represent an important influence on student behavior as well as form a vital link between the implementation of effective teaching and classroom management strategies that result in student learning" (p. 33).

Summary

The literature has shown that quality math teaching involves effective math teachers with training in math pedagogy who can help a variety of students to learn valuable mathematical content (Ball et al., 2005). The effective teacher's goal is to prepare students for math success in the 21st century (Pasquinelli, 2011). Effective math teachers have a depth of knowledge that is demonstrated in how well they understand mathematics, the conceptual foundations of that knowledge, and how well the teacher is able deliver the math instruction in the learning environment (Ball et al., 2005). Teachers' math professional knowledge starts with teacher preparation programs that are crucial for equipping teachers with the skills needed to be an effective math instructor. These preparation programs are responsible for providing the preservice teacher with a broad conceptual knowledge of the mathematics that they will teach, equipping the teacher candidates with a deep understanding of the mathematics content knowledge in numbers and operations and affording them numerous opportunities for practice prior to entering the classroom (NCTM, 2015).

The math knowledge and proficiency that math teachers need is sustained with ongoing learning. This learning requires in-service workshops, PD, professional readings, and other professional activities that provide all math teachers with opportunities to collaborate on content and focus on the methods of teaching math. Such professional activities will also increase teachers' confidence in math teaching and thus increase their math teaching efficacy (Polly et al., 2013), which has been connected to student math achievement.

Section 3: Research Method

Introduction

In this chapter, I describe the study design and approach that I used to examine how teacher-related factors may influence low fifth-grade math achievement and the decline in math achievement between third and fifth grades that was observed in two southeastern U.S. school districts (i.e., CSD1 and CSD2). I detail the guiding research questions and hypotheses, methodology, study setting and sample, instrumentation and materials, data analysis. I also address ethical considerations.

Research Design and Approach

In this study, I used a quantitative prediction design to determine whether factors related to teachers' knowledge of mathematics content and pedagogy (i.e., years of experience teaching mathematics, hours of PD in math pedagogy, number of completed college-level math content courses, number of teacher preparation courses in mathematics instruction, and mathematics teaching efficacy) predict student mathematics achievement in third and fifth grades. I also explored how well the teacher factors predict the grade level taught in an effort to explain the decline in mathematics achievement that occurs from third to fifth grade. I conducted this study in two rural school districts in the southeastern United States, CSD1 and CSD2, between 2017 and 2018 (IRB approval #12-13-16-0237642) to address the following research questions and their corresponding hypotheses:

Research Question 1: Do teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) significantly predict student math achievement in third and fifth grades?

$H_0$1: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do not significantly predict student achievement in third and fifth grades.

H_a1: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do significantly predict student math achievement in third and fifth grades.

Research Question 2: Do teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) predict grade level taught?

$H_0$2: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do not significantly predict grade level taught.

H_a2: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do significantly predict grade level taught.

I used binary logistic regression analysis as the appropriate statistical test for this study. The explanatory variables, or the teacher factors, measured were years of teaching experience, hours of PD in math pedagogy, college-level math courses completed, teacher preparation courses in mathematics, and math teaching efficacy as measured by the MTEBI. The dependent variables, or criterion variables, were student math achievement and grade level taught. My study objective was to learn how teacher factors predicted student math achievement and to determine whether or not these factors could determine the grade level taught to explain the achievement decline between third and fifth grades. For a small-scale study such as this with several predictor or independent variables that have continuous and categorical data, a quantitative study design using regression analysis was appropriate.

Setting and Sample

CSD1 had a diverse population of over 19,000 students. According to the State Department of Public Instruction, approximately 3,000 of these students were in the third and fifth grades at the time of the study. The State Department of Public Instruction reported that the student ethnic population was 50.8% White; 25.2% African American/Black; 17.3% Hispanic; and 6.8% Pacific Islander, Asian multiracial, or American Indian. According to the State Department of Public Instruction, CSD2 also had a diverse population and enrolled a total of 54,000 students, with approximately 24,000 of these students in the third and fifth grades. CSD2's student ethnic population was 45.21% White, 29.77% African American/Black, 13.04% Hispanic, 1.82% Asian, 1.71% Native American, 0.45% Hawaiian Pacific, and 7.9% other.

I used a convenience sampling method comprised of willing participants who were available for the study (see Creswell, 2012). The sample included only third- and fifth-grade math teachers from the two school districts included in this study. Sample size is important to this type of quantitative study because it can increase the validity of the findings (see Creswell, 2012). According to Creswell (2012), the minimum number of participants needed for a correlational regression study that relates variables is 30 participants. Because I studied two grade levels with five variables, the minimum number of participants should have been 75. To verify the correct sample size, I performed a power analysis using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009). The power analysis revealed that with an effect size (f^2) of 0.35, an alpha (α) equal to 0.05, and a power of 0.80, the study needed a minimum of 27 participants in each group. In CSD1 and CSD2, there were a total of 575 third- and fifth-grade teachers, meaning that there were sufficient potential participants to achieve the proper sample size. To reduce the potential for error in the population and increase the generalizability of the results, all currently employed third- and fifth-grade teachers in CSD1 and CSD2 were invited to participate in the study.

Instrumentation and Materials

Mathematics Teaching Efficacy Belief Instrument (MTEBI)

I used the math-adapted MTEBI (Enochs et al., 2000) in this study with the publisher’s permission (see Appendix A). The MTEBI is a 21-item survey that uses a 5-

point Likert scale (i.e., 5 = *Strongly Agree,* 4 = *Agree,* 3 = *Uncertain,* 2 = *Disagree,* and 1 = *Strongly Disagree)* to measure teachers' personal beliefs about teaching mathematics and their beliefs about how their math instruction affects student achievement (see Appendix A). Of the 21 items on the questionnaire, 13 items ask about the participants' personal math teaching efficacy and the remaining items ask about their expected mathematics teaching outcomes.

The MTEBI was appropriate for this study because it is a reliable and valid measure of teaching efficacy. The Cronbach's alpha test of reliability verified the MTEBI with scores of 0.88 for the personal teaching efficacy portion and 0.75 for the teacher outcome expectancy portion (Enochs et al., 2000). The MTEBI was tested for validity using a confirmatory factor analysis (CFA; Enochs et al., 2000). The CFA statistical procedure tested the hypothesis that there was a relationship between the observed variables and their underlying hidden constructs (Intellectus Statistics, 2017). From the CFA analysis, the MTEBI was deemed valid because the pattern indicated that the instrument tested what it was designed to test (Enochs et al., 2000). I received permission for use of the MTEBI in this study through written correspondence with the author and publisher via e-mail (see Appendix A).

Demographic Survey

Teacher participants also completed a short, multiple-choice, demographic information survey so I could collect data about the independent variables (see Appendix B). The data were used to determine the number of participants from the sample that participated in the variable categories.

Data Collection and Analysis

Data Collection

I used Kwiksurvey to collect the participant demographic data (see Appendix B) and the MTEBI to assess teacher efficacy. All participants received the Kwiksurvey link in the invitation to participate in the study. The Kwiksurvey link provided the participants with access to the demographic survey and MTEBI questionnaire. Together, the MTEBI questionnaire and the demographic questions were estimated to take about 30 minutes to complete. I assured all teachers in writing that their participation was anonymous and the information they provided would remain anonymous.

I collected and used three types of data in this study: (a) demographic data, (b) MTEBI scores, and (c) student math achievement scores. Through the short, demographic survey, I asked participants what grade they taught, their years of teaching experience, their number of completed hours of PD in math pedagogy, their number of completed college-level math courses, and their number of completed teacher preparation courses. Participant MTEBI scores were also collected. Finally, the end-of-grade (EOG) test scores for third-grade students in 2009, and the test scores from the same students in fifth-grade in 2012 for CSD1 and CSD2 were collected from public sources. All data were downloaded and stored in a password-protected, computer file.

Student-Level Data Collection

The study did not involve collecting any information directly from students. I collected the student math achievement data from the CSD1 and CSD2 county report card website from the state's Department of Public Instruction. The only scores collected and used in this study were the math student achievement data measured by the EOG tests for third-grade students in 2009 and fifth-grade students in 2012 students. The student scores were downloaded from the site electronically. No personally identifiable information was attached to the student scores from the district website.

Descriptive and Inferential Analysis

To analyze the data, I used SPSS Version 24. First, I conducted a descriptive analysis of the data to determine the percentage of participants for each of the predictor variables by grade level. Then, I used a regression analysis to test the predictive relationship of the independent and dependent variables. According to Creswell (2009), in a regression analysis, the variations of the dependent variables will be explained by the variance of each independent variable as well as the combined effect of all independent variables. Because there was a combination of categorical and continuous independent and dependent variables that I needed to test for relationships, I chose to use a binary logistic regression analysis. The binary logistic regression analysis allowed for the relationships between the variables to be nonlinear and the independent variables to be continuous or categorical as well as for testing the combined effects of single or multiple variables with or without the effects of the other variables. The results of the binary logistic regression analysis determined whether the predictor variables (i.e., teaching experience, hours of PD in math pedagogy, college-level math courses completed, teacher preparation courses taken, and math teaching efficacy) related to student mathematics achievement. The results also indicated how well the variables determined the grade level taught.

Protection of Participants' Rights

I conducted this study in CSD1 and CSD2 in accordance with the standards of the National Institutes of Health (Protecting Human Research Participants, 2011). All the participants were over the age of consent, read the invitation to participate, and indicated that they understood and agreed to participate in the study by completing the survey. The anonymous participant data and the student EOG math scores from the district website were downloaded into an electronic computer file and securely stored. The data will be maintained for 5 years and then destroyed.

Role of the Researcher

My role during the research was strictly that of a researcher. I am currently employed as a fourth-grade teacher in a different school district than where the study was conducted. I have no personal contact with the teachers and staff members in CSD1 or CSD2. I did not have any influence on the scores or access to personal or confidential information about study participants in CSD1 or CSD2. Both CSD1 and CSD2 permitted the research solely as cooperating partners, and their only interest was in the results of this study on teacher factors that affect low math achievement in fifth grade and a decline in math achievement between third and fifth grades.

Section 4: Results

Introduction

The rural southeastern U.S school districts in this study, CSD1 and CSD2, have shown a decline in math achievement between the third and fifth grades. This decline is part of the larger trend of low math achievement in the United States, where many students do not master mathematics at their grade level and math proficiency declines with increasing grade level (NCES, 2017). In an attempt to investigate math achievement decline between third and fifth grades in these two school districts, I explored some of the teacher-related factors (i.e., teaching experience, PD, college math courses, math teacher preparatory courses, self-efficacy, and output efficacy) that research has shown can predict student math achievement (see Ball, 2011; Darling-Hammond, 2009).

Data Management

The sample for this study consisted of 61 participants. Data collected from these participants had to be prepared and cleaned following multiple steps prior to analysis. First, I compiled the survey data in Excel and checked for any missing data. There were no missing data from the demographic questionnaire or the MTEBI. Next, I assessed the data for outliers using Tabachnick and Fidell’s (2013) procedure and looked for values larger than or less than 3.29. I found scores for self-efficacy and output efficacy (i.e., continuous variables) measured by the MTEBI with values of 97 and 100, respectively, and I removed these outliers from the dataset. At this point the raw data were cleaned and ready for analysis. I imported the cleaned data into SPSS Version 24 and performed the appropriate tests for the logistic regression analysis, including statistical assumptions, model fit, and descriptive statistics. Finally, I copied the data, generated SPSS tables, and saved the information in a protected file for referral.

Data Analysis

Descriptive Statistics

The sample of 61 participants consisted of 29 third-grade teachers and 32 fifth-grade teachers. Among the third-grade teachers, the largest percentage of participants had 6–9 years of teaching experience (*n* = 13, 44.8%), while the two largest percentages of fifth-grade teachers had 10–20 years of experience (*n* = 11, 34.4%) or over 20 years of experience (*n* = 11, 34.4%). A majority of third-grade teachers (*n* = 15, 51.7%) had 21–36 hours of PD in math pedagogy, while slightly more fifth-grade teachers had the same amount of PD hours (*n* = 17, 53.1%). A majority of both third- (*n* = 17, 58.6%) and fifth-grade teachers (*n* = 18, 56.3%) had completed three to five college math courses. A majority of third-grade teachers had completed two to five math teacher preparation courses (*n* = 18, 62.1%), while the two largest groups of fifth-grade teachers had completed two to five courses (*n* = 15, 46.9%) or over six courses (*n* = 15, 46.9%).

In terms of teaching efficacy, third-grade teachers had a slightly lower mean self-efficacy score (*M* = 35.24, *SD* = 3.83) than fifth-grade teachers (*M* = 37.00, *SD* = 4.00), but both groups scored similarly for output efficacy (third grade: *M* = 26.72, *SD* = 3.56; fifth grade: *M* = 26.13, *SD* = 5.36). The majority of CSD1 and CSD2 third-grade teachers had students with math achievement scores in the 66%–68% range (*n* = 27, 93.1%). All of the CSD1 and CSD2 fifth-grade teachers had students with math achievement scores in the 57%–59% range (*n* = 32, 100.0%). Table 1 presents frequencies and percentages, and Table 2 presents the ranges, means, and standard deviations of the self-efficacy and the output efficacy scales.

Table 1

Frequencies and Percentages of Predictor Variables

Variable	3rd grade teachers		5th grade teachers	
	n	%	*n*	%
Experience				
1–5 years	1	3.4	1	3.1
6–9 years	13	44.8	9	28.1
10–20 years	10	34.5	11	34.4
20+ years	5	17.2	11	34.4
Professional development				
None	0	0.0	1	3.1
1–12 hours	2	6.9	1	3.1
13–20 hours	12	41.4	13	40.6
21–36 hours	15	51.7	17	53.1
College math courses				
None	3	10.3	3	9.4
1–2 courses	1	3.4	1	3.1
3–5 courses	17	58.6	18	56.3
6–8 courses	8	27.6	10	31.3
Math teacher preparation courses				
None	0	0.0	1	3.1
1 course	1	3.4	1	3.1
2–5 courses	18	62.1	15	46.9
6+ courses	10	34.5	15	46.9
Math Achievement				
(57%–59%)	2	6.9	32	100.0
(66%–68%)	27	93.1	0	0.0

Table 2

Results of Efficacy Scale Scores

Variable	3rd grade teachers				5th grade teachers			
	n			%	*n*			%
	Min	Max	*M*	*SD*	Min	Max	*M*	*SD*
Self-efficacy	28.00	41.00	35.24	3.83	28.00	44.00	37.00	4.00
Output efficacy	19.00	34.00	26.72	3.56	16.00	40.00	26.13	5.36

Inferential Statistics

In order to answer the research questions posed in this study, I performed two binary logistic regressions. This is the appropriate analysis to perform when assessing the relationship between a series of categorical or continuous predictor variables and a single dichotomous dependent variable (Tabachnick & Fidell, 2013). The dependent variables in this study, math achievement and grade level taught, are both dichotomous, so a binary logistic regression was appropriate.

I performed each regression with the same predictor variables: teaching experience, PD, college math courses, math teacher preparatory courses, self-efficacy, and output efficacy. Due to the nature of the regression, it was necessary to dummy code the variables with multiple categories (Field, 2013). Additionally, due to low frequencies, I combined some of the variable categories (see Table 1). This recoding resulted in two variables for years of experience: 1–9 years and 10–20 years, with 20+ years as the reference category; two variables for college math courses: three to five courses and six to eight courses, with zero to two courses as the reference category; and two variables for math teacher preparatory courses: two to five courses and six or more courses, with zero to one course as the reference category.

Table 3

Dummy Variables Recoding in Two Variables

Variable	*B*	*SE*	Wald	*Sig.*	*Exp(B)*
Experience					
1–9 years	1.60	0.81	3.91	.048	4.96
10–20 years	1.13	0.82	1.92	.166	3.11
Professional development					
13–20 hours	0.49	1.29	0.15	.702	1.64
21–36 hours	0.79	1.27	0.38	.536	2.19
College math courses					
3–5 courses	0.12	0.95	0.02	.901	1.13
6–8 courses	0.17	0.98	0.03	.864	1.18
Prep math courses					
2–5 courses	0.57	1.41	0.16	.686	1.77
6+ courses	0.47	1.43	0.11	.745	1.59
Teaching efficacy					
Self-efficacy	-0.04	0.08	0.24	.628	0.96
Output efficacy	0.11	0.08	1.83	.177	1.12

Note. Experience reference is 20+ years, professional development reference is 0 to 12 hours, college math courses reference is zero to two courses, and prep math courses reference is zero to one course.

Because the binary logistic regression was dichotomous, a nonparametric test using the binary logistic regression was most appropriate (Field, 2013). The nonparametric test does not necessitate stringent assumption testing; however, the analysis does require that there be no outliers in the data and no extreme multicollinearity (Tabachnick & Fidell, 2013). I removed outlier values from the data set and assessed the predictor variables for multicollinearity using variance inflation factor (VIF) values. VIF values above five indicate moderate correlations amongst the predictor variables, but values above 10 indicate extreme multicollinearity and are a cause for concern (Stevens, 2009). All VIF values were below 10, indicating that the assumption was met. Table 4 presents the VIF values.

Table 4

VIF Values

Variable	VIF
Experience	
1–9 years	1.81
10–20 years	1.71
Professional development	
13–20 hours	4.93
21–36 hours	4.87
College math courses	
3–5 courses	2.69
6–8 courses	2.47
Math teacher preparatory courses	
2–5 courses	5.69
6+ courses	5.75
Teaching efficacy	
Self-efficacy	1.39
Output efficacy	1.26

Research Question 1

The first research question and corresponding hypotheses addressed in this study were:

Research Question 1: Do teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) significantly predict student math achievement in third and fifth grades?

$H_0 1$: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do not significantly predict student achievement in third and fifth grades.

H_a1: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do significantly predict student math achievement in third and fifth grades.

To test the null hypothesis of this question, I performed a binary logistic regression with the predictor variables and the dependent variable of student math achievement. When comparing groups using the binary logistic procedure, one group needs to be identified as the reference category (see Tabachnick & Fidell, 2013). The Hosmer and Lemeshow (2013) test was used to check the adequacy of the model. In this test, results that are statistically significant would indicate a poorly fit model. The Hosmer and Lemeshow test statistic was not significant ($p = .675$), indicating a moderate model fit (see Tabachnick & Fidell, 2013). The model was able to correctly classify placement into either group of the dependent variable 61% of the time.

The results of the overall regression were not significant ($\chi^2(10) = 8.09$, $p = .620$), indicating that the combination of predictors did not significantly predict placement into either category of math achievement. There was one individually significant dummy-coded variable, 1–9 years of teaching experience ($OR = 4.96$, $p = .048$). This indicated that teachers with 1–9 years of experience were 4.96 times more likely to have students with higher math achievement than those with 20+ years of experience. No other individual predictor variable was significant. Based on these results, the null hypothesis of Research Question 1 was rejected. Table 5 presents the full results of this analysis.

Table 5

Results of the Binary Logistic Regression Predicting Math Achievement

Variable	*B*	*SE*	Wald	*Sig.*	*Exp(B)*
Experience (ref: 20+ years)					
1–9 years	1.60	0.81	3.91	.048	4.96
10–20 years	1.13	0.82	1.92	.166	3.11
Professional development (ref: 0 to 12 hours)					
13–20 hours	0.49	1.29	0.15	.702	1.64
21–36 hours	0.79	1.27	0.38	.536	2.19
College math courses (ref: 0 to 2 courses)					
3–5 courses	0.12	0.95	0.02	.901	1.13
6–8 courses	0.17	0.98	0.03	.864	1.18
Prep math courses (ref: 0 to 1 course)					
2–5 courses	0.57	1.41	0.16	.686	1.77
6+ courses	0.47	1.43	0.11	.745	1.59
Teaching efficacy					
Self-efficacy	-0.04	0.08	0.24	.628	0.96
Output efficacy	0.11	0.08	1.83	.177	1.12

Note. $\chi^2(10) = 8.09$, $p = .620$; ref = reference category

Research Question 2

The second research question and corresponding hypotheses addressed in this study were:

> Research Question 2: Do teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) predict grade level taught?

$H_0$2: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do not significantly predict grade level taught.

H_a2: Teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) do significantly predict grade level taught.

To test the null hypothesis for Research Question 2, I performed a binary logistic regression with the predictor variables and the dependent variable of grade level taught in order to determine whether different teacher factors predicted the grade level taught. The reference category of grade level taught was third grade. The Hosmer and Lemeshow test was significant (p = .024), indicating a poor model fit (see Tabachnick & Fidell, 2013). The model was able to correctly classify placement into either group of the dependent variable 62.7% of the time.

The results of the overall regression were not significant, which means that there was insufficient evidence to conclude that teacher factors predicted math achievement in either grade level ($\chi^2(10) = 87.60$, p = .668). This indicated that the combination of predictors did not significantly predict placement into either grade level. There were no individually significant predictor variables. Therefore, the null hypothesis was accepted. Table 6 presents the full results of this analysis.

Table 6

Results of the Binary Logistic Regression Predicting Grade Level Taught

Variable	*B*	*SE*	Wald	*Sig.*	*Exp(B)*
Experience (ref: 20+ years)					
1–9 years	-1.19	0.78	2.34	.126	0.30
10-20 years	-0.94	1.32	0.24	.622	0.52
Professional development (ref: 0 to 12 hours)					
13–20 hours	-0.65	1.32	0.24	.622	0.52
21–36 hours	-0.84	1.29	0.42	.518	0.43
College math courses (ref: 0 to 2 courses)					
3–5 courses	-0.20	0.93	0.04	.833	0.82
6–8 courses	-0.02	0.96	0.00	.981	.977
Prep math courses (ref: 0 to 1 course)					
2–5 courses	-0.77	1.39	0.31	.578	0.46
6+ courses	-0.46	1.41	0.11	0.74	0.63
Teaching efficacy					
Self-efficacy	0.07	0.08	0.70	.403	1.07
Output efficacy	-0.10	4.77	0.22	.642	9.19

Note. $\chi^2(10) = 87.60$, $p = .668$; ref = reference category

Summary

I performed two binary logistic regressions to ascertain how teacher factors (i.e., years of teaching experience, hours of PD in math pedagogy, college-level math courses, math teacher preparatory courses, and teaching efficacy) predicted math achievement in third and fifth grades. Research Question 1 asked whether the teacher factors significantly predicted math achievement. Based on the results of the binary logistic regression, the null hypothesis of Research Question 1 was rejected. Having between 1–9 years of teaching experience predicted an increased likelihood of higher student math achievement when compared to teachers with over 20 years of experience. Research Question 2 asked whether the teacher factors could predict whether a teacher taught third or fifth grade. Based on the results of the binary logistic regression, the null hypothesis of Research Question 2 was accepted. No teacher factor was significantly predictive of grade level taught. In Section 5, I will provide a discussion of the study results, interpreting and discussing the findings within the context of the relevant literature. I will also provide a discussion of implications for social change and recommendations for further research.

Section 5: Discussion, Conclusions, and Recommendations

Introduction

Students who do not develop math skills in the early stages of their learning are likely to lack the necessary skills that form the foundation for more advanced mathematics courses (NCES, 2017). In the two, rural southeastern U.S. school districts in this study (i.e., CSD1 and CSD2), there has been a decline in math achievement between the third and fifth grades. This decline is part of the larger trend of low math achievement in the United States, where many students do not master mathematics at their grade level and math proficiency declines with increasing grade level (NCES, 2017).

I conducted this quantitative, prediction study to investigate if teacher-related factors (i.e., years of teaching experience, hours of PD in math pedagogy, college-level math courses, math teacher preparatory courses, and teaching efficacy) predicted math achievement in third and fifth grades. Demographic information and MTEBI scores were collected from third- and fifth-grade teachers in CSD1 and CSD2, along with student math achievement scores, and analyzed with binary logistic regression analyses to address the following research questions:

> Research Question 1: Do teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level math content courses, number of math teacher preparation courses, and teaching efficacy) significantly predict student math achievement in third and fifth grades?
>
> Research Question 2: Do teacher factors (i.e., years of experience, number of hours of professional development in math pedagogy, number of college-level

math content courses, number of math teacher preparation courses, and teaching efficacy) predict grade level taught?

Based on the results of the binary logistic regressions, I was able to reject the null hypothesis of Research Question 1 but was unable to reject the null hypothesis of Research Question 2. These findings are discussed in the following sections, along with their implications for social change and my recommendations for action and further study.

Interpretation of Findings

The analysis results for Research Question 1 revealed that of the five predictor variables (i.e., years of teaching experience, hours of PD in math pedagogy, college-level math courses, math teacher education preparatory courses, and math teaching efficacy), teacher experience showed the most significant predictive ability for student math achievement. Teachers with 1–9 years of teaching experience were 4.96 times more likely to have students with higher math achievement than teachers with more than 20 years of teaching experience. This finding appears to conflict with previous research (i.e., Ball et al., 2005; Darling-Hammond, 2009; Ekmekci, Corkin, & Papakonstantinou, 2015) that found more experienced teachers to be more effective teachers. However, research conducted by Papay and Kraft (2016) supported the results of this study. Papay and Kraft examined the relationship between teaching experience and student math achievement using an estimated growth model to predict how long teachers continued to improve student achievement over the course of their career in a large, urban U.S. school district. The researchers found that teachers with 1–10 years of math teaching experience in teaching math improved student achievement scores. Papay and Kraft explained this by pointing out that teachers in the beginning years of their career tend to demonstrate the most student growth in test scores due to the teachers' investment in teaching improvement during this period. This may explain the significant results in my study for teachers with 1–9 years of experience. Teachers with 1–9 years of experience may have learned more updated teaching methods and mathematic content knowledge from their teacher preparation classes that allowed them to help their students achieve higher scores than students taught by more experienced teachers.

The other predictive variables tested, hours of PD in math pedagogy, college math courses completed, math teacher education preparation courses, and math teaching efficacy were not significant according to the binary logistic regression test. Papay and Kraft (2016) found that student achievement was more evident early in teachers careers even though teachers improved their teaching throughout their careers. The teacher-related factors in this study did not predict the grade level taught, although the model was able to classify the placement of the dependent variable 62% of the time. The regression models for Research Question 2 did not provide substantial evidence that teacher factors in this study significantly predicted placement into third or fifth grades.

Previous research (e.g., Corkin, Ekmekci, & Parr, 2018) examining teachers' beliefs, attitudes, math efficacy, teacher value, motivation, experience, and grade level taught may provide some insight into these findings. Corkin et al. (2018) conducted a quantitative study with 217 K-12 math teachers in Texas public schools to investigate the extent to which factors associated with teachers' school-work environment predicted teacher self-efficacy and intrinsic value for teaching math. The researchers found significant correlations between the school-work environment and teachers' beliefs related to math teaching efficacy and self-efficacy. Although my study did not focus on the school environment, I did measure teacher factors, including math teaching efficacy, self-efficacy, and years of experience, to determine grade level taught. Of particular relevance was Corkin et al.'s finding that teachers' self-efficacy and math teaching efficacy was negatively affected during the high-stakes testing period due to low levels of principal support. The researchers stated that the results were consistent with previous studies demonstrating that principals directly and indirectly affect teacher job satisfaction and retention. Corkin et al. also posited that the social relationships teachers develop with administrators enhance their commitment to teaching. In the present study, it is possible that the self-efficacy and math teaching efficacy scores of the teachers in CSD1 and CSD2 across both grade levels were influenced by low levels of support received from their principals, specifically during the high-stakes testing period, which might explain the lack of evidence that teacher factors significantly predicted placement into third or fifth grades.

The descriptive statistics provided frequencies and means for each of the variables collected from the demographic survey and the MTEBI teaching efficacy and efficacy outcome scores. Of the 61 participants, third- (n = 29) and fifth-grade teachers (n = 32) demonstrated consistent frequencies. Third-grade teachers had a slightly lower mean self-efficacy score (M = 35.24, SD = 3.83) than fifth-grade teachers (M = 37.00, SD = 4.00). These results of the self-efficacy test from my study indicated that teachers had a high to moderate self-efficacy, with the mean score of fifth-grade teachers slightly higher than that of third-grade teachers. Teachers in both grades had similar outcome efficacy scores (third-grade teachers: $M = 26.72$, $SD = 3.56$; fifth-grade teachers: $M = 26.13$, $SD = 5.36$).

I did not find that teacher efficacy predicted student math achievement. Teacher efficacy scores among third- and fifth-grade teachers in this study indicated that they had a moderate to high confidence in their ability to teach math to their students; however, the teachers scored low in self-efficacy outcome expectancy (third grade: 19–34, fifth grade: 16–40) on the MTEBI. These results on teaching efficacy conflict with previous research that found a positive relationship between teaching efficacy and student achievement (Chang, 2015; Polly et al., 2013). Chang (2015) examined the impact of math teaching efficacy on student mathematical achievement to determine whether teachers' efficacy beliefs predicted their students' math self-efficacy and found that math teacher efficacy was significantly related to student efficacy and math achievement. Similarly, Polly et al. (2013) found a significant positive relationship between teacher math practices and beliefs and student learning outcomes.

Although the third- and fifth-grade teachers in this study demonstrated moderate to high teaching efficacy scores, they did not believe that their teaching could positively affect student math achievement based on their outcome efficacy scores. Furthermore, the teaching efficacy scores could have high variance due to the documented variance in teacher practices, measurement tools, and data analysis found in previous studies (Barrett et al., 2015; Papay & Kraft, 2016; Polly et al., 2013; Stronge et al., 2011). To fully understand how teaching beliefs, teaching efficacy, teacher mathematical instructional practices, and student learning outcomes are related, further research is needed using a larger sample.

Although the results of my study conflicted with some previously published results on this topic in the literature, research, overall, continues to support the theories of Ball and McDiarmid (1989) on subject matter content, the knowledge preparation of teachers as discussed by Shulman (1986), and self-efficacy by Bandura (1997). A practical interpretation of these study findings suggests that teachers with 20+ years of experience need to engage in PD activities that develop their math content knowledge and pedagogical knowledge (see Jong, 2016; Papay & Kraft, 2016; Patton, Parker, & Tannehill, 2015; Vega & Hederich, 2015) needed to address the inconsistent teaching efficacy scores between newer teachers and those with over 20 years of teaching experience. Researchers have shown that effective teaching is possible in districts when effective PD is designed to improve student math achievement outcomes (Chang, 2015; Jong, 2016; NCTM, 2015; Papay & Kraft 2016; Patton et al., 2015; Polly et al., 2013).

Implications for Social Change

In this study, I investigated whether teacher-related factors (i.e., years of experience, PD in math pedagogy, college math courses, math teacher preparation courses, and teaching efficacy) predicted student math achievement in third and fifth grades. With this study also determined whether these teacher factors predicted the grade level taught to explain the math achievement decline observed between third and fifth grades in CSD1 and CSD2. The results showed that the teacher factors did not significantly predict grade level taught. The results also revealed that teachers with 1–9 years of experience were more likely to have students with higher math achievement than teachers with more than 20 years of teaching experience.

The literature has shown that to increase student math achievement, teachers need to possess in-depth math knowledge and well-developed pedagogical skills that align with their math teaching (Jong, 2016). To meet these needs, professional learning support is essential (NCTM, 2015). If CSD1 and CSD2 district administrators and teachers improve math instruction using the information gained in this study, specifically for teachers with over 20 years of experience, it will have a positive social impact on their students and communities. Improving the quality of math instruction and teaching outcome efficacy in mathematics in CSD1 and CSD2 will improve student math achievement. Increased student math achievement could indirectly lead to an increase in high school graduation rates and attendance in postsecondary schools for these school districts and the communities they serve.

Recommendations for Action

Based on my findings, I have one recommendation that is intended to improve teacher math instruction in CSD1 and CSD2, with the goal of increasing student math achievement.

Recommendation 1: Professional Development (PD)

Some experienced teachers may require PD to educate them about currently accepted teaching methods (Jacob, Hill, & Corey, 2017). Nontraditional approaches, such as student-centered learning and inquiry, have been found to be more effective teaching approaches that teachers should apply to improve student achievement (Jacob et al., 2017). Research has shown that improving the quality of teaching instruction requires content-specific PD that emphasizes skills for teaching math (Barrett et al., 2015; Darling-Hammond, 2011; Jong, 2016; Shulman, 1986). Content-specific PD is needed to improve knowledge and teaching methods throughout CSD1 and CSD2, specifically for teachers with over 20+ years of teaching experience.

To ensure that teachers have the necessary knowledge for building students' math foundation, including the ability to teach about what math is and make sure students understand how to "do" math (NCTM, 2015), they should participate in PD activities focused on math pedagogy. This may involve learning how math instruction helps students understand math and how to develop students' understanding of the number system (NCTM, 2015). According to the NCTM (2015) teachers of third through fifth grades, should receive PD on how to investigate solutions using everyday math problems, with a focus on the processes and relationships between addition, multiplication, subtraction, and division. Teachers should engage in activities where they gain knowledge in multiplicative reasoning, equivalence, and a variety of methods for computation in the content topics (NCTM, 2015). Such an approach to PD of math teachers is supported by the research of Firmender, Gavin, and McCoach (2014) and NCTM (2015) regarding the importance of teachers actively engaging students in an in-depth, challenging mathematics curriculum during early childhood education.

The dominant discourse within both of the theories included in the theoretical framework of this study is teacher content knowledge. Although not discussed in the frameworks explicitly, teachers must update their knowledge base (Jong, 2016). Teaching professionals are expected to process and evaluate new knowledge to improve their professional practice and learn the most efficient ways to help students learn. Effective, content-specific PD is critical to helping teachers increase their content knowledge in math.

When teachers are provided ongoing, content-based training experiences in mathematics through PD, teacher quality improves and student math achievement increases (Barrett et al., (2015). Barrett et al. argued that limited access to successful PD may explain the difficulty that teachers face when trying to improve student achievement in rural locations. The researchers also found that math teaching supported by effective PD experiences positively impacted student achievement over time (Barrett et al., 2015). When CSD1 and CSD2 administrators and school leaders use the results from this study to consider providing effective PD to their teachers, they will enable their teachers to access the best current teaching methods and update their content knowledge to improve their teaching practice and increase student learning.

Recommendations for Further Study

I have two recommendations for future research based on my findings. The first is additional research regarding teacher content knowledge. The second is a case study to observe successful math teachers and learn about their strategies for supporting student achievement.

Recommendation 1: Teacher Content Knowledge

Based on the results of my study, I recommend that a qualitative study be conducted to explore the content knowledge needed to successfully teach math in third and fifth grades. A survey and interview on content knowledge could generate data from teachers about what they believe is necessary for mathematics teaching. Such a study would provide valuable information about the necessary math content knowledge to successfully teach third- and fifth-grade mathematics.

Recommendation 2: Case Study

To precisely determine which teacher factors may affect student achievement, I recommend the use of a case study approach. Unlike the approach I used in this study (i.e., a binary logistic regression), the use of a case study design to investigate this relationship would allow for a more in-depth exploration and extensive data collection (see Creswell, 2009). The recommended case study would focus on the most effective, well-trained math teachers in the district to identify what teacher-related factors influence their effective teaching style. A qualitative study design such as this would illuminate how successful mathematics teachers from the third and fifth grades are able to teach math effectively.

Conclusion

In this quantitative study, I investigated the relationship between teacher-related factors and low math achievement among third- and fifth-grade students in two school districts in the southeastern United States. Several teacher factors related to teacher knowledge of mathematics content and pedagogy (i.e., teaching experience, PD in math pedagogy, college math courses completed, teacher preparation courses in mathematics, and teaching efficacy) were tested to determine whether they could predict student mathematics achievement and grade level taught. Sixty-one teachers took part in the study, which consisted of the MTEBI and a demographic survey. I analyzed the data using a binary logistic regression analysis to determine the existence of relationships between teacher factors and student achievement or grade level taught. In general, the results revealed that these teacher factors did not significantly predict student math achievement or grade level taught. One variable, teaching experience, was significantly related to higher student math achievement for teachers with 1–9 years of experience.

Researchers indicated that the teacher-related factors I studied are related to student math achievement. Even though the results of my study demonstrated that the combination of teacher factors did not show a positive relationship between all variables, I learned that teachers with 20 + years of experience would benefit from PD designed to develop their mathematical content knowledge and pedagogy.

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Appendix A: Publisher Permission

Predictive Factors of Student Mathematics Achievement Decline Between Third and Fifth Grade

Original E-mail
From : LARRYENOCHS
Date : 05/10/2013 03:58 PM
To : Jean Salters [jean.salters@waldenu.edu]
Subject : Re: Request Permission

Your study sounds good. Please feel free to use the instrument. You should use it as described in the article. Feel free to contact to me regarding the study.

Professor
Science and Mathematics Education
231 Weniger Hall
Oregon State University
Corvallis, OR 97331

"Students should continue to learn and use their learning in more effective problem solving for the rest of their lives. When one takes life-long learning and thinking as the major goal of education, knowledge becomes a means rather than an end, and other formerly implicit goals become more explicit." (McKeachie et al, 1986, p1.)

Appendix B: Demographic Survey Questions

Predictive Factors of Student Mathematics Achievement Decline Between Third and Fifth Grade

1. **At what grade level do you presently teach?**

A 3

B 5

2. **For how many years have you been teaching elementary school mathematics at your current grade level?**

A 0–5

B 6–9

C 10–20

D 20 or more

3. **Approximately how many hours of professional development in math pedagogy have you completed? (Professional development hours are defined as workshops, face to face or online hours that are accepted by your district.)**

A 1-–12 hours

B 13–20 hours

C 21–36 or more hours

D None

4. **Approximately how many college level math content courses have you completed?**

A 0–2 course
B 3–5 courses
C 6–8 courses
D 9 or more

5. **When you attended a teacher education program (undergraduate and/or graduate) how many teacher preparation courses in mathematics pedagogy did you complete?**

A 1 course
B 2–5 courses
C 6 or more courses
D None