2024

THE IMPACT OF TEACHER DEVELOPMENT, STUDENT SELF-EFFICACY, AND STUDENT ACCESS AND EFFORT ON FOURTH-GRADE MATH ACHIEVEMENT

Steven Borst

THE IMPACT OF TEACHER DEVELOPMENT, STUDENT SELF-EFFICACY, AND STUDENT ACCESS AND EFFORT ON FOURTH-GRADE MATH ACHIEVEMENT

A dissertation submitted in partial fulfillment
of the requirements for the degree of

DOCTOR OF EDUCATION

to the faculty of the

DEPARTMENT OF ADMINISTRATIVE AND INSTRUCTIONAL LEADERSHIP

of

THE SCHOOL OF EDUCATION

at

ST. JOHN'S UNIVERSITY

New York

by

Steven Borst

Date Submitted March 27, 2024

Date Approved May 17, 2024

Steven Borst

Dr. James R. Campbell

ABSTRACT

THE IMPACT OF TEACHER DEVELOPMENT, STUDENT SELF-EFFICACY, AND STUDENT ACCESS AND EFFORT ON FOURTH-GRADE MATH ACHIEVEMENT

Steven Borst

This study examines the effects of self-efficacy, students' effort and access to educational resources, and teachers' development on the achievement of elementary school students in mathematics. Using the 2013 National Assessment of Educational Progress (NAEP) restricted data set, this study determined if and how these three aspects individually and in combination affected performance on the fourth-grade NAEP math assessment. The NAEP is referred to as The Nation's Report Card, guiding educational practice and policy through the assessment of a large, diverse sample from the entire United States (NAEP, 2013a). This non-experimental study addresses the issues of declining test scores in the United States alongside some of the many factors that are thought to contribute to educational achievement (OECD, 2019; NAEP, 2017). By approaching the study through the lens of self-efficacy (Bandura, 1986), constructivism (Bruner, 1960), and mathematical knowledge for teaching (Hill et al., 2005), relevant variables were selected from NAEP, reduced to factors, and used in regression analyses to better understand the ongoing downward trend in international math assessment scores. The findings of this work contribute to the field of education by providing insight into how issues outside the classroom can impact student achievement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

Student achievement in mathematics is related to many factors, including teaching effectiveness (Adnot et al., 2016), self-efficacy (Blândul, & Bradea, 2022), and access to educational assistance (Muñez et al., 2021). While prior research has reported relationships between and suggestions for improving math instruction and achievement, it has focused on in-service teachers, secondary education, and college-level math methods courses. The present study investigates the potential for interactions between students' math achievement and their teachers, the effect of such interactions, and students' effort and access to helpful resources.

Elementary teachers may not receive in-depth training in the math content they will be teaching in the U.S. (Ma, 1999). Receiving this training while in service may increase the effectiveness of teachers. This study explores how teachers' professional development interacts with student achievement. Different instructional strategies, including providing explanations for solutions and making real-world connections, have been successful in other countries with elementary students (House, 2009). These instructional strategies suggest ways to improve student performance. Moreover, Shone et al. (2024) found the perception and self-efficacy of high-school students to be good indicators of performance on assessments. Therefore, additional research is required to determine the impact of both internal and external factors on student performance.

Purpose of the Study

The purpose of this study was to examine if factors such as student self-efficacy, student effort and access, and teachers' professional development influence elementary students' math achievement. This study used the restricted data set of the National

Center for Education Statistics (NCES) National Assessment of Education Progress (NAEP) fourth-grade math results from 2013 to determine if these factors affect mathematics performance. This is a non-experimental quantitative study that uses factor analysis and linear regression.

The NCES is part of the U.S. Department of Education's Institute of Education Sciences (IES). Additionally, the NCES is the primary statistical agency of the U.S. Department of Education and is federally required to report the condition of American education while also reviewing the state of international education (NCES, n.d.). The NCES uses the NAEP, also known as The Nation's Report Card, to "provide important information about student academic achievement and learning experiences in various subjects" (NCES, 2024). The results of NAEP assessments are important as they inform policymakers, educators, and researchers of trends and possible methods to improve the teaching of students in various locations and groups. The NAEP also keeps other public stakeholders, such as parents and the media, informed of educational progress in the U.S. (NCES, 2019). NAEP assesses ten subject areas in grades 4, 8, and 12: civics, economics, geography, mathematics, music and visual arts, reading, science, technology and engineering literacy, U.S. history, and writing.

Students, teachers, and administrators answer questionnaires as part of the NAEP assessments. Students also answer content-based assessment questions. For this study, questions from the student questionnaire about their effort in math and math self-concept were used to create student-facing factors. Questions regarding teachers' experience of professional development were used to create a teacher-facing factor. Finally, questionnaire responses on class size and absenteeism were included to examine the possible ramifications of focused instructional time within schools. These factors and variables were compared to the performance of the students on the fourth-grade math NAEP assessment to determine if correlations exist between factors/variables and performance.

Significance of the Study

The math achievement of school-age students has been analyzed throughout history in the U.S. since at least 1969 (Hutt & Schneider, 2018; NCES, n.d.a.), with the U.S. falling short of recent goals (NCES, 2019; Organisation for Economic Cooperation and Development [OECD], 2019). The U.S. has consistently ranked below average on the math section of the Programme for International Student Assessment (PISA) when compared to other participating countries. In 2018, the U.S. had mean scores above the international mean in both reading and science but below the international mean in math (OECD, 2019). The NAEP is used to assess growth and proficiency within the U.S. While there was no significant difference between the scores in 2015 and 2017 for fourth graders in math, there was a significant decrease between 2013 and 2017 (NCES, 2019). Although there was a significant increase of one point from 2017 to 2019, scores are still lower on average than in 2013. Only 41% of students reached proficiency in 2019, compared to 40% in 2017 (NCES, 2019). Exploring the perceptions of students, access to math help outside of school, and the training of teachers is necessary to determine how students may learn best and why recent scores show a declining trend.

The present research aims to inform educational practice and interest. By identifying areas of concern both within and outside schools, policy changes can reflect these concerns and potentially change the downward trajectory of achievement in math in the U.S.

Theoretical Framework

This study is rooted in three theories of education. The first is mathematical knowledge for teaching (MKT). This theory asserts that effective math teachers must possess adequate knowledge in math, which consists of both subject matter knowledge and pedagogical content knowledge (Ball et al., 2005). As teachers increase their MKT, student outcomes improve. Elementary math teachers with strong MKT possess skills that outsiders from other professional fields are not aware of and that are not necessarily required in other non-teaching math fields, such as understanding how and why algorithms work, analyzing students' errors, and providing quick feedback on inventive strategies from students (Ball et al., 2008; Hill et al., 2005).

The second theory contained in the conceptual framework regards self-efficacy, that is, one's perceived ability. Student self-efficacy is based on personal, behavioral, and environmental factors (Bandura, 1986), as well as student motivation and performance. This makes self-efficacy important to the current study, as student performance in math may be affected by self-efficacy (Schunk, 2016). Self-efficacy is also influenced in a large part by happenings at school. Self-efficacy in math is specifically important, since students can have different levels of self-efficacy in specific academic subjects (Artino, 2012).

The final theory incorporated into this conceptual framework is constructivism, specifically the constructivist theories of Jerome Bruner (1960). Bruner (1960) believed that children need to be taught at their current cognitive levels to learn best. Bruner also believed that discovery and exploration were vital for learning. This explains his theory that learning in math should first focus on concrete experiences before gradually moving toward the abstract. His thoughts on curricula led him to the view that a "spiral curriculum" that revisits old topics from a new, cognitively appropriate perspective is best for learning. Bruner also believed that internal motivation was more powerful than external motivation, especially in terms of grades, and that motivation levels were dependent on meaningful outcomes. As a result, children make academic decisions based on their perceived correlation between effort and outcome.

These three theories, through their connections and commonalities, have been used to create the theoretical framework for this study. The theories connect knowledge and skills of teachers (MKT) (Ball et al., 2005), perception of one's own ability (self-efficacy (Bandura, 1986), and meaningful knowledge acquisition (constructivism) (Bruner, 1960).

Research Design and Research Questions

The research design of this study consists of two major parts. The first part is a principal components analysis (PCA), which is closely related to and even often referred to as a factor analysis (Meyers et al., 2017). The purpose of the PCA is to determine which of many variables from many items correlate. This creates an inventory of factors to use as independent variables. Variables with strong relationship strengths can be combined into one factor (Meyers et al., 2017).

The second part of the statistical analysis is regression analysis. Using the determined factors and the scores assigned to students on the NAEP, whether each factor significantly correlates with the achievement of the students can be determined.

The research questions focus on how students with access to differently trained teachers, different levels of additional help outside of school, and different levels of self-efficacy about their math ability perform on the NAEP assessment. The research questions are rooted in the theoretical framework of this study and are created with the aim of determining how content and pedagogical knowledge, self-efficacy, and constructivism influence student achievement. Taking these areas of need and theories into account, the research questions are as follows:

1. Does student self-efficacy about mathematics ability influence success in elementary mathematics?
2. Do students' efforts in math and their access to help from materials and people outside of school influence success in elementary mathematics?
3. Does the professional development that teachers receive influence the mathematics achievement of their students in elementary grades?
4. Do these three elements in combination contribute to students' success in elementary mathematics?

Null Hypotheses

$H_0$1: There is no relationship between student self-efficacy and student success in mathematics.

$H_0$2: There is no relationship between the access to help and effort of students and student success in mathematics.

$H_0$3: There is no relationship between teachers' professional development and student success in mathematics.

$H_0$4: The combination and interaction of these factors do not affect student success in elementary mathematics.

Definition of Terms

Access: The level of educational opportunities available to students outside of school, including but not limited to technology, tutoring, and physical resources.

MKT (Mathematical Knowledge for Teaching): MKT is the mathematical knowledge used to conduct the *work* of teaching math, including explaining concepts, judging curricula and student work, using representations accurately, and providing examples of math concepts (Hill et al., 2005).

Professional Development: The training that current teachers receive on important topics in education.

Self-Efficacy: The feelings about oneself and one's ability to succeed and achieve goals. Often used interchangeably with efficacy, this study considers self-efficacy to be strictly limited to perception. Efficacy is limited to actual performance in this study.

Summary

Mathematics education and outcomes are analyzed in the U.S., with outcomes often falling below targets (NAEP, 2017; OECD, 2019). Therefore, the intent of this study is to determine the impact of specific variables on student achievement. Using the fourth-grade NAEP survey answers and test results, this study analyzes how self-efficacy, access to help, teacher development, class size, and absenteeism affect math achievement through factor and regression analyses. The results can help shape educational policy, both inside and outside of schools.

CHAPTER 2 REVIEW OF RELATED RESEARCH

Chapter 2 first provides a conceptual framework for this study. Three theories are combined to create a lens that is unique to this study. Each of these theories is identified, elaborated on, and linked to the current study. Then, the review of related literature examines prior research in topics closely related to this study, including emotions and effort in school, access to educational resources, and teacher training.

Theoretical Framework

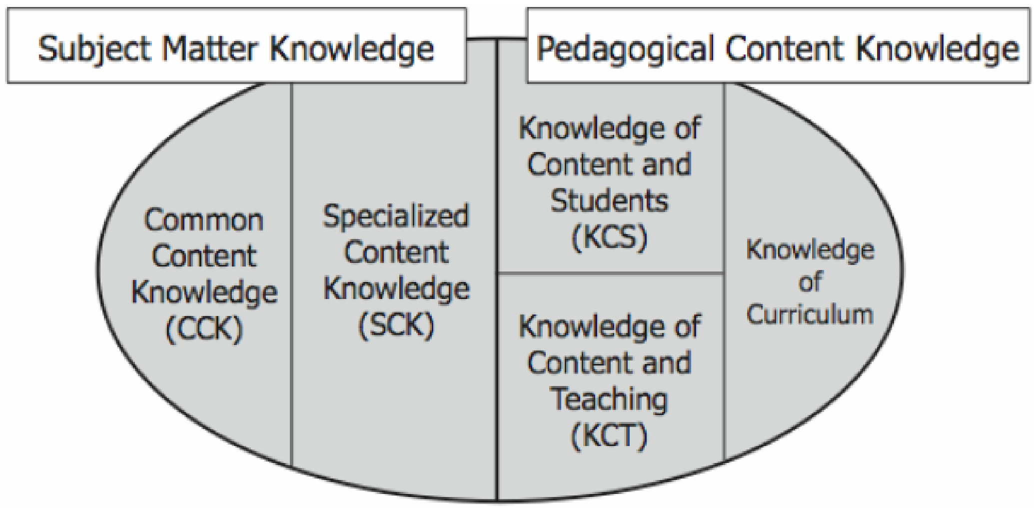
The theoretical framework for this study combines MKT (Hill et al., 2005) with student self-efficacy (Bandura, 1986) and the constructivist theory of Bruner (1960). All three theories are pertinent to this study. MKT relates to teacher training, which is one factor in this study. Self-efficacy and constructivism are included in this theoretical framework to create a lens through which student effort and emotion can be analyzed.

Mathematical Knowledge for Teaching

MKT (Hill et al., 2005) is based on the concept that math teachers must possess a specific type of content knowledge, called content knowledge for teaching (CKT). This research is built from Schulman's (1986) categorical scheme, which described a need for teachers to have subject matter knowledge as well as pedagogical content knowledge. An expansion of this model for teaching by Ball et al. (2008) can be seen in Figure 1. In teaching math, this means that a teacher must have knowledge of students and math content, and their specific math content knowledge should go beyond what is simply needed to solve a problem. This specialized content knowledge also includes concepts such as being able to analyze and find the root of errors, solve problems in multiple ways, and explain math conceptually. These are skills that math educators need are not necessarily required in other math fields that do not require teaching math concepts.

Figure 1

Map of the Domain of Content Knowledge for Teaching



Ball et al., 2008

Higher levels of MKT predict higher levels of student gains in mathematics (Hill et al., 2005). If the goal of math instruction is for students to develop mathematical understanding, students should understand why math concepts and procedures work and relate to each other, as well as mathematical substance (Ball, 1990). Teacher preparation programs for elementary math often do not take this into account. These elementary school topics are perceived as simple and paired with the idea that "if you can *do* them, you can teach them" (Ball, 1990, p. 462). Fortunately, teachers and potential teachers who receive this type of instruction can improve their MKT through content-focused professional development and content courses in preservice programs (Hill et al., 2005).

Truly knowing math for teaching requires elevated levels of analysis. Teachers must be able to visually understand a concept, not simply use an algorithm (Hill et al., 2005). While algorithms are effective and efficient, teachers should explain why the algorithm works and the meaning behind each step (Ball et al., 2008). Teachers also must identify correct strategies that they may have never seen before and determine whether these strategies will always work for the same type of problem. For example, if a student comes up with an inventive strategy for multiplication but it works only by coincidence, the teacher must intervene to prevent the student from continuing to use that strategy for multiplication. Moreover, teachers must use clear, unambiguous language when defining vocabulary and concepts (Ball et al., 2008).

When teaching, teachers must be thoughtful not only in the strategies they teach, the models they use, and the explanations they give but also in the numbers they choose (Ball et al., 2005). A good model problem sets students up for success in solving similar problems in the future. This example shows how pedagogical thought along with mathematical content knowledge are used in unison, further supporting the theory that MKT consists of both. Ball et al. (2008) sum up the mathematical tasks of teaching with a list of requisites. The requisites relevant to this study are as follows: presenting mathematical ideas; responding to students' "why" questions; finding an example to make a specific mathematical point; linking representations to underlying ideas and other representations; connecting a topic being taught to topics from prior or future grades; modifying tasks to be either easier or harder; evaluating the plausibility of students' claims (often quickly); giving or evaluating mathematical explanations; and asking productive mathematical questions.

Self-Efficacy

The seminal work by Bandura (1982) described self-efficacy as the beliefs about one's abilities and capabilities and one's perception of their potential to perform. This perception is only how one predicts they will perform, not an actual measurement of performance. It must be noted, however, that past performance and levels of success will influence self-efficacy in future endeavors. Self-efficacy is not general and how a student feels about their ability in one task will differ from how they feel about another task (Artino, 2012). Ergo, a student who has high self-efficacy in math may not have high self-efficacy in another subject, such as writing.

Since self-efficacy is based on perception, it influences how students choose tasks, persist in tasks, apply effort, and acquire skills (Schunk, 2016). Students tend to be enthusiastic about and willing to undertake tasks they believe they can complete. Bandura (1986) identified three key sources of self-efficacy: personal factors, such as learning disabilities; behavioral factors, such as effort; and environmental factors, such as treatment by peers and teachers. These sources interact in a bidirectional manner, meaning any one source can affect any other, therefore impacting self-efficacy.

Self-efficacy plays an important role in learning. Students develop their level of self-efficacy based on teacher feedback and expectations, peer expectations and comparative performance, and the classroom culture and environment (Schunk, 2016). Since self-efficacy is linked to academic decision-making, effort, follow-through/perseverance, and willingness to learn, it is often attributed to the actual performance of students.

Self-efficacy also influences the actions of teachers, including persistence, resilience, enthusiasm, how they react to student errors, and how likely they are to stay in the teaching profession (Tschannen-Moran et al., 1998). Teacher self-efficacy can be broken into categories that are either internal or external (Gibson & Dembo, 1984). Internal categories are under the teacher's control, while external factors (such as demographics and mandates) are not. Among internal categories, there are unstable categories, such as effort, and stable categories such as ability (Guskey, 1982).

Initially, Guskey (1982) found that teachers generally attributed successful classes to internal causes and unsuccessful classes with external causes out of their control. He described these internal (unstable) and external (stable) categories as the basic elements in measuring the self-efficacy of teachers. It is important to note that elementary teachers were more likely to attribute lack of success to internal causes than secondary teachers. Guskey and Passaro (1994) expanded on this by discovering that internal and external causes were not necessarily related. Teachers felt they could make a difference despite inhibiting external factors or that they are limited in their abilities to affect children regardless of external factors.

Constructivism

Jerome Bruner's theory of constructivism is rooted in the idea that children learn best when their problem-solving skills are fostered and when the subject matter is appropriate for their cognitive level (Bruner, 1960). Bruner believed that any student could learn any topic to some extent if their teacher met them at their level. This belief was connected to his ideas about a "spiral curriculum," which revisits the same topics at more advanced levels as learners progress. Bruner (1960) states, "Giving the material to them in terms they understand, interestingly enough, turns out to involve knowing the mathematics oneself, and the better one knows it, the better it can be taught" (p. 40).

Bruner (1960) found inquiry, exploration, and discovery to be important in learning. He emphasized introducing new math topics with the use of concrete methods that a child can understand and without the use of abstract math notation. His progression from enactive to iconic to symbolic (Schunk, 2016) mirrors modern mathematical teaching techniques that encourage students to start with the concrete and then move to the visual before exploring the abstract. This contrasts with many methods of teaching that Bruner was exposed to, which encouraged rote memorization. Bruner (1960) even suggested an early math and science "pre-curriculum" to build the intuitive knowledge needed later in life. Bruner (1960) states:

> The effect of such an approach would be, we think, to put more continuity into science and mathematics and also give the child a much better and firmer comprehension of the concepts which, unless he has this early foundation, he will mouth later without being able to use them in any effective way. (p. 46).

Parts of Bruner's learning theory closely relate to self-efficacy. He wrote about how grades may be an external influence for motivation, but understanding is a stronger motivator and to replace understanding with grades would be detrimental and lead to a lack of motivation once a student leaves school and no longer receives grades. In this sense, a "learning episode" as Bruner (1960) describes it, can only last until one is fatigued. A child's endurance for learning depends on how the outcome relates to the effort.

Connections to the Study

The use of these theories is specific and necessary to this study because they all apply to effective teaching and learning. The NAEP includes survey items pertaining to these theories. Teachers' perceptions and knowledge (MKT) influence student self-efficacy, which in turn affects students' knowledge acquisition. In connecting these three areas, this study explores how students' sense of ability, students' learning experiences and opportunities, and teachers' knowledge and training affect math learning in elementary grades.

Literature Review

The following literature review summarizes studies pertaining to influences of math instruction and achievement. It is organized based on the research questions and theoretical framework of the study. First discussed is research based on the impact of effort and emotions on academic achievement, followed by student access to resources, and lastly teacher training and development.

Self-Efficacy, Emotions, and Achievement

Self-efficacy has been used as a predictor of academic achievement and performance on assessments. Blândul and Bradea (2022) examined how perceived self-efficacy affected awareness of actual academic ability. Their study was on 108 university-level students and showed that students who perform best have the highest levels of self-efficacy and self-awareness. This led to the presumption that self-awareness is a crucial part of psycho-intellectual and psycho-emotional development. Blândul and Bradea (2022) assert:

Students with a very high level of perceived self-efficacy demonstrate superior

> self-assessment skills, as demonstrated by an objective assessment of their own academic performance. These students seem to be aware of their own professional and personal value, have confidence in their own abilities, and are willing to take on learning tasks that they can successfully complete. (p. 300).

Oppong-Gyebi et al. (2023) researched the impact of self-efficacy on Science, Technology, Engineering, and Math (STEM) achievement in Ghana among high school students. Their findings were similar to those of Blândul and Bradea (2022) in that positive self-efficacy had a positive impact on math achievement. Their findings did not indicate any significant effects of the perception of mathematics on achievement in math or science. The researchers attributed this to the fact that students had already chosen general sciences as a focus for their education, knowing that math electives were a requisite. Additionally, they attribute a substantial amount of mathematical achievement to "mathematical connectedness." This is a measure of how students saw math's connectedness to the real world, science, technology, and engineering.

Self-efficacy and emotions overlap. Yu et al. (2022) investigated this relationship, examining emotional self-efficacy, self-regulation, motivation, and academic performance. Their study focused on the learning of 318 Chinese students with a mean age of 24 taking online classes and found a significant relationship between self-regulation and emotional self-efficacy. They also found that learning motivation is a predictor for emotional self-efficacy. When examining academic achievement of students, only emotional self-efficacy was a statistically significant predictor.

Koray and Bilgin (2023) investigated the effect of using Scratch, a block-based coding program, on student perceptions. They worked with 22 sixth graders in Turkey and found that Scratch significantly increased the computational thinking skills of students. Additionally, they found that Scratch caused a significant increase in student self-efficacy in relation to block-based coding and science. Though training can cause increases in self-efficacy, determining specific types of training that do this most efficiently can be beneficial (Koray & Bilgin, 2023). Finally, the study found that students had positive attitudes toward the Scratch activities, suggesting that the type of activity that students perform in class affects motivation and self-efficacy.

Educational Access

Access in education refers to many aspects of the potential to learn and learning enhancements. Access is often connected to socioeconomic status (SES), as students who come from families with more money have more capital to spend on educational resources. In the 21st century, technology has a growing role in education but access to this technology is dependent on the technology that students have at home and in school. Similarly, schools have resources that students can use such as books and classroom supplies. The more resources a school has, the more resources its students can access. Finally, people provide educational access. The familial view of education, the amount of help received from family members, and access to tutors all differ between students.

Muñez et al. (2021) examined the home mathematics environment (HME) and its effect on the math achievement of kindergarteners. HME was determined using survey responses from parents, with items about topics such as encouraging mental math, singing counting songs, playing games involving math, and discussing money and time. The Test of Early Mathematics Ability-3 was used to assess the math knowledge of the children. The researchers found that only addition and subtraction activities had a significant positive relationship with ability, indicating that children of parents who do these activities at home are more successful in kindergarten math. While basic math activities at home did not have a significant positive association, and in some instances had a significant negative association, Muñez et al. (2021) assert that this finding may be caused by the various levels of understanding children have of math when entering kindergarten. This in turn affects which skills parents focus on most closely. The research of Muñez et al. (2021) also found that SES and HME contribute to math ability independently and that the amount of home math activities relates to the mother's education and not the household income.

SES contributes to performance in other aspects of math for young children. Short and Mclean (2023) researched the numerical mapping ability of four- and five-year-olds in Scotland, how it predicts future math achievement, and how it correlates with SES. Numerical mapping is when a person takes a symbolic representation of a number and translates it to a numeral in a number system and vice versa (Short & McLean, 2023). They found that mapping activity performance was a significant predictor of math achievement and that children of low SES performed significantly worse at mapping activities. They note that this finding is not surprising as low SES is often associated with low achievement. However, their study also showed that not all low-SES children had low performance, which they attribute to potential differences in opportunities provided by parents regardless of SES and caregiver attitudes toward education. They also note that the impact of SES varies by culture.

Zhang et al. (2020) explored the effects of SES and parental involvement in older children. Working with 815 fourth to sixth graders in China, they measured family SES, parental involvement, and parents' subjective social mobility. Comparing these to the academic achievement of students in both mathematics and Chinese, they found that SES positively correlated with academic achievement and that SES determined family involvement, which in turn affected academic achievement. However, the correlation between SES and parental involvement was weak when parents had high subjective social mobility. This suggests that parents who believed they could increase their social class were more involved in their child's teaching despite their low SES.

Moliner et al. (2022) researched peer tutoring alongside math digital tools for ninth graders. The experimental group scored significantly higher in all math domains than the control group who did not receive peer tutoring or digital tools interventions. Additionally, students who were in the experimental group were more enthusiastic about learning mathematics than their peers who did not have a tutor or digital tools.

Teacher Training and Knowledge

Teachers receive many different types and levels of training both before and throughout their careers. Research demonstrates the link between the content knowledge of teachers and instructional styles. Teachers obtain content and pedagogical knowledge through their preservice programs in college and through in-service professional development. The balance between content knowledge and pedagogical knowledge is highly debated, and different countries approach teaching knowledge through different means with varying results.

Ma (1999) examined math instruction in elementary schools in China and the U.S. and found that although teachers in the U.S. receive a much higher level of math education, teachers in China had a better fundamental understanding of the elementary math that they would be teaching. Through examining how these teachers taught subtraction with regrouping, multiplication of multi-digit numbers, division of fractions, and area and perimeter concepts, she found that over 80% of Chinese teachers in the study held a strong conceptual understanding of math, while less than 20% of American teachers had such a strong understanding. Regardless of the country, teachers without a strong conceptual understanding stuck to procedures when teaching math but while they could explain these procedures, they could not tell why they worked (Ma, 1999). Teachers with a strong conceptual understanding were able to explain why an algorithm worked and could teach math procedurally and conceptually, almost always teaching multiple approaches to solving math problems. One difference between American teachers and Chinese teachers is that while most used manipulatives as a concrete strategy for teaching math, Chinese teachers connected these strategies to other procedures and other math topics, while American teachers often used manipulatives in a way that contradicted the algorithm. Ma also found that teachers projected their attitudes toward math onto their students. For example, teachers who had positive attitudes toward mathematical inquiry were more likely to encourage students to find their own strategies for solving math problems. This study highlights not only the differences between the two countries' math programs but also the importance and relevance of international math programs to the U.S.

Izsák et al. (2019) completed a study of 653 in-service middle-grade teachers and the depth of their conceptual understanding of fractions by looking for a strong understanding of why the four operations (addition, subtraction, multiplication, and division) with fractions worked, not simply if the teachers could complete the problems.

They also asked teachers to solve problems in multiple ways and use specific models to solve them and found that many teachers did not have mastery of the fraction concepts they were teaching. Ultimately, they determined that “U.S. middle-grades teachers with strong preparation in math, high school teaching experience, and preparation in a secondary program have significantly outperformed those without similar experiences in various measures of math content knowledge” (p. 189).

Both Ma (1999) and Izsák et al. (2019) explored the value of content knowledge for teaching math in the elementary and middle grades and concluded that content knowledge is not a useful indicator of teaching ability in math. Ma (1999) found that teachers with less content knowledge could be more effective math teachers if they had a deeper understanding of the topics they were teaching. The U.S. model of teaching high-level math, such as calculus, was inferior to the Chinese model of emphasizing a rich understanding of the foundations. Similarly, Izsák et al. (2019) showed that teachers with similar amounts of content knowledge could have different levels of success in teaching middle-grade students. However, generally, quality teaching required more than just knowing how to solve math problems, thus supplementing Ma’s (1999) research. While China and the U.S. are different culturally and these cultures can influence math learning, the juxtaposition of Ma’s (1999) and Izsák et al.’s (2019) research shows similarities in effective math instruction between the two countries.

The content and pedagogical knowledge of teachers have long been studied for their association with student performance. A study in Peru suggested that teachers with a stronger understanding of content led to higher performance of students (Cueto et al., 2017). The results from this study were taken from a larger study called “Young Lives”, which contained 12,000 children over the course of 15 years in four countries. There were 312 students from Peru involved in the study, with one teacher per two students. The School Survey instrument from Young Lives was used to obtain the results. It was given toward the end of the school year, after students had almost a full year of instruction from teacher participants. Socioeconomic status was the single most important feature when determining potential academic success. Students with higher SES had access to teachers with a better understanding of content knowledge, in addition to other advantages such as more resources at home.

Campbell et al. (2014) found that teacher knowledge (pedagogy), content knowledge, and SES had statistically significant effects on student achievement in math in upper elementary grades. School districts in Delaware, Maryland, and Pennsylvania participated by providing student achievement and demographic data linked to individual teachers. A total of 226 upper-elementary and 193 middle-grade early-career teachers volunteered to participate. One source of data was the student state tests. The SES of students was determined by whether they received free or reduced-price lunches. Teacher experience was measured by the number of years teaching, number of years teaching math, degrees, certifications, and number of courses taught. Teachers also took a 120-question multiple choice test, with 40 questions measuring pedagogical content knowledge and 40 questions measuring content knowledge. The teachers also took a Likert-scale survey regarding their own mathematical beliefs and awareness, which was developed by Campbell et al. (2014) for the study. There was a statistically significant positive relationship between teacher content knowledge and student state test scores. Socioeconomic status had a significantly negative effect on student test scores. These findings about in-service teachers led the researchers to propose specialized teachers and departmentalization for upper elementary grades.

The studies of Cueto et al. (2017) and Campbell et al. (2014) both indicate the impact SES has on math achievement. Cueto et al. (2017) even singled it out as the most crucial factor in student achievement. However, the studies also show that teachers influence student achievement, and their influence is based on multiple factors. Campbell et al. (2014) explored various other factors through quantitative methods, finding that content knowledge and pedagogical content knowledge also affect student achievement. Although the SES of students cannot be immediately changed by teachers, increases in content and pedagogical knowledge can influence student achievement. Cueto et al (2017) discovered that a major reason SES mattered was that students of high SES had access to higher-performing schools where teachers had elevated levels of content knowledge.

There is a crossover between content knowledge and pedagogy, as previously described through the research of Campbell et al. (2014). For example, Lannin et al. (2013) describe the ability of teachers to solve math problems but the inability to help students who make an error on a math problem. To do this, a teacher must understand the concept while also having teaching skills. A teacher lacking in one or both skills will often fail to adequately address the misconceptions of students, a skill that others in non-teaching math fields would not require. (Ball et al., 2005).

Pedagogical knowledge does not always yield higher student achievement. A study in Belize on the training and content knowledge of teachers found that teacher training did not have a significant effect on student outcomes (Mullens et al., 1996);

however, teachers with higher levels of content knowledge in math led to students doing better in math. These findings relate to those of Ma (1999) who suggested that more math education does not help a teacher if their fundamental math skills are weak while Mullens et al. (1996) suggest that teacher training has no effect if it does not strengthen content knowledge. A higher level of education for teachers may not have any effect on student achievement but math content knowledge was crucial in both studies.

The findings of Mullens et al. (1996) somewhat contradict the previously reviewed studies on content and pedagogical knowledge. Their findings oppose those of Lannin et al. (2013) in that content knowledge without pedagogical knowledge positively affected student achievement. This raises issues in how content knowledge is measured since it is not uniform. Content knowledge may be considered to be how deeply a teacher understands the content they are teaching; Ma (1999) expressed the importance of this. It may also refer to the level of math that a teacher has achieved, such as how many college courses they have passed. Again, this sheds light on the difference between being able to solve a problem and understating precisely why and how learned procedures (and alternate approaches) work in both abstract math and real-world scenarios.

Since the advent of the Common Core Learning Standards (CCLS), changes in math education have taken place throughout the U.S. Published in 2010 and endorsed by the National Council for Teachers of Mathematics, 43 states, the District of Columbia, four territories, and the Department of Defense Education Activity (DoDEA) adopted the CCLS over the next few years (Akkus, 2016). The intention of the Common Core was to increase rigor, coherence, and focus, emphasizing depth over breadth and logical sequencing more than past standards (Akkus, 2016). It is important to note that the

CCLS are not a curriculum, and therefore can be approached differently in different locales.

The Common Core includes content standards and practice standards; the former describes what students should be learning while the latter describes behaviors and strategies that can help students achieve content mastery, such as building number sense and reasoning skills (Burns, 2013). The new standards were developed with the intent of increasing achievement by aligning standards with successful countries and states (Schmidt & Burroughs, 2013). Between the new refined content standards and the practice standards, the CCLS looked at many of the issues addressed in this study and which are still present today. Researchers have studied teacher preparation programs to determine the content knowledge, pedagogical knowledge, beliefs, and attitudes of preservice teachers. Studies have also examined if teacher preparation programs influence these topics and if there are relationships between these topics. Newton et al. (2012) examined the relationships between math content knowledge and teacher efficacy of preservice teachers during an elementary math methods course. They broke teacher efficacy into personal teaching efficacy and outcome expectancy and found that content knowledge and teacher efficacy had a strong, stable correlation throughout the methods course. Conversely, Swars et al. (2007) found that preservice teachers enrolled in two math methods courses over two semesters had significant shifts in beliefs related to both pedagogical and specialized content knowledge throughout the courses. This difference may be the result of the diverse types of teacher preparation programs, different time frames, or other outlying factors.

A phenomenological report completed by Valentine and Boylard (2019) explored when shifts in perceptions and abilities in math occurred during preservice programs. Through interviews with teachers, they found that shifts in math self-efficacy took place when math was connected to the real world and when rich discussions took place. They also determined the factors that were detrimental to self-perceptions of math ability, which were disconnection from former teachers, being excluded from activities, being unwillingly included in activities, and relations with family members and peers.

Using grounded theory to analyze interviews of four preservice teachers with differing levels of math self-efficacy, Swars (2005) determined three themes related to perceptions of math teaching effectiveness. First, past experiences with math resulted in lower math teaching efficacy. Second, perceptions of math teaching differed based on math teaching efficacy. While all participants believed they could teach math effectively, those with lower efficacy believed it would take more time and effort. Third, teachers had different beliefs regarding instructional strategies in math based on their math teaching efficacy. Teachers who had lower efficacy stuck to strategies they learned in school and felt less comfortable with techniques such as using manipulatives, but all participants believed that authentic and real-world learning experience was necessary in math instruction.

Burton (2012) had similar findings about math in the real world. Preservice teachers were asked to draw their perceptions of math before and after a math methods course. Initially, 32 participants had negative emotions in their drawings and 21 had neutral emotions. The only positive drawings of math included the real world, with nine participants including the real world in their drawings. After the course, the drawings of all 62 participants included relations to the real world. The number of participants who had negative emotions in their post-course drawings was zero while the number of participants who had positive emotions in their drawings was 38; the other 24 participants had neutral emotions.

While previously reviewed studies have addressed classwork experiences, Mewborn (1999) examined the role of fieldwork on teacher growth in preservice programs. She found that early field experience can have positive effects on preservice teachers' learning about teaching math, contrary to prior research. Preservice teachers also benefitted from their community and having peers to rely on during coursework.

Hiebert et al. (2019) examined specialized content knowledge in preservice teachers and how its development in preservice programs affects knowledge for teaching math. They found, similar to Ma (1999), that a focus on fewer topics led to a deeper understanding of these topics. The drawback was that fewer topics could be studied. Additionally, teaching the content knowledge necessary for teaching math required hands-on experience like that which elementary teachers use in their classrooms, which helps teachers to understand the errors that their students make and the unorthodox solutions they may come up with. The study was longitudinal and the researchers found that only some of the learning was retained once preservice teachers were employed as teachers and that concepts needed to be retrained. They emphasized that the differences in teacher preparation programs mean that their study cannot necessarily be replicated elsewhere.

Hart et al. (2013) examined the issue through a different lens by analyzing instructor perspectives along with student perspectives on math methods courses.

Instructors and students both agreed that affect (such as anxiety and efficacy) is crucial in teaching and learning math. The researchers proposed addressing this issue more thoroughly in teacher preparation programs, especially since instructors feel constrained in their ability to address their students' anxiety. The students' anxiety increased with drill and practice activities and decreased with hands-on, student-centered, small group activities. Preservice teachers believed that they should practice the types of problems they will be teaching, which strengthens Ma's (1999) assertion that having a better fundamental understating of math is more important than having a higher level of math education.

Mewborn (1999) and Hiebert et al. (2019) make a case for teacher preparation programs allowing preservice teachers to see and learn how elementary students learn. The lack of retention when entering the teaching field discovered by Hiebert et al. (2019) raises concerns about theory versus practice and whether maintenance is necessary. Hart et al. (2013) discovered that methods used in Hiebert et al.'s study (such as hands-on experience) also help with math anxiety and that preservice teachers appreciated a focus on addressing their math anxiety. With the time constraints that Hiebert et al. (2019) encountered, this may leave even less time for addressing math anxiety in preservice programs. The consequences of the training and knowledge that teachers have adds more concerns regarding teachers in education, along with the issues that students themselves face.

Summary

The theoretical framework of this study includes three theories pertaining to teaching and learning. Self-efficacy (Bandura, 1982, 1986), MKT (Hill et al., 2005), and constructivism (Bruner, 1960) come together to create a framework that is used as a lens to design this study and conduct research. The literature details important aspects related to this study. Recent research often addresses content and pedagogical knowledge separately or for in-service teachers specifically. Research has also addressed the effect of self-efficacy on teacher ability and student outcomes. Studies regarding teacher preparation programs are important to this study and the reviewed literature provides an analysis of the successes and shortcomings of current teacher preparation programs. The literature guides this study along with the theoretical framework.

CHAPTER 3 METHODS

Chapter 3 describes the research design used in this study. First, the research questions are restated. Next, the techniques for administering and scoring the NAEP are discussed, including the sample and population for NAEP. Lastly, the research design and analysis processes are explained.

Methods and Procedures

Research Questions

1. Does student self-efficacy about mathematics ability influence success in elementary mathematics?
2. Do students' efforts in math and their access to help from materials and people outside of school influence success in elementary mathematics?
3. Does the professional development that teachers receive influence the mathematics achievement of their students in elementary grades?
4. Do these three elements in combination contribute to students' success in elementary mathematics?

Null Hypotheses

$H_0 1$: There is no relationship between student self-efficacy and student success in mathematics.

$H_0 2$: There is no relationship between the access to help and effort of students and student success in mathematics.

$H_0 3$: There is no relationship between teachers' professional development and student success in mathematics.

H_04: The combination and interaction of these factors do not affect student success in elementary mathematics.

The NAEP Assessment

This is a non-experimental study using data from the 2013 NAEP grade 4 math assessment restricted data set, which was obtained through St. John's University. This is a non-experimental study since it used secondary data already obtained by the IES. The NAEP is used as a measure of long-term achievement in the U.S. and has been gathering information about educational progress since 1973 (National Assessment Governing Board [NAGB], 2013). The NAGB created an assessment framework for the NAEP, which determines what math skill students should be assessed on in grades 4, 8, and 12 and then creates test items to assess these skills. These test items do not indicate how math should be taught, only whether students have attained these skills. Results are broken down into three achievement levels (NAGB, 2013):

- "Basic" denotes partial mastery of prerequisite knowledge and skills that are fundamental for proficient work at each grade.
- "Proficient" represents solid academic performance for each grade assessed. Students reaching this level have demonstrated competency over challenging subject matter, including subject-matter knowledge, application of such knowledge to real-world situations, and appropriate analytical skills.
- "Advanced" represents superior performance.

These three levels are the primary, straightforward way of reporting NAEP data and are not indicative of what students should be able to do in mathematics.

Sample and Population. The sample size and target population for NAEP mathematics at grade 4 in 2013 were 189,600 and 3,895,000 respectively (NAEP, 2013a). A total of 52 jurisdictions participated in this NAEP exam (Table 1). All 50 states participated, as well as the District of Columbia and the DoDEA. Data is collected from both public and private schools. The sample size has been rounded to the nearest hundred and the target population has been rounded to the nearest thousand by NAEP (2013a). The number of participating schools by jurisdiction ranged from 50 to 230, with the number of students by jurisdiction ranging from 2,500 to 7,300. These numbers varied based on the enrollment size of the jurisdiction (NAEP, 2013a). Students from participating schools were randomly sampled from a roster of eligible individuals.

Table 1

School and Student Participation in Fourth-Grade 2013 NAEP Math

Jurisdiction	Number of Schools Participating	Number of Students Assessed
Nation	7,930	186,500
Public Schools	7,450	180,200
Private Schools	280	3,100

(NAEP, 2013a)

NAEP Administration and Data Collection. The NAEP assessment is administered to students during the school day and each student that takes the NAEP assessment only takes one subject area. The assessment takes between 90 and 120 minutes to complete, including a student survey (NAEP, 2019). NAEP provides students with all necessary materials and required test-taking accommodations, as may be specified by individualized education plans for example. Additional data that is collected includes teacher questionnaires on training and instruction, as well as school questionnaires, which are typically filled out by school administrators. All responses to the NAEP assessment are private (NCES, 2019).

Along with survey questionnaires, data obtained by NAEP includes math performance of students. For survey questionnaires, NAEP uses weighting procedures to create a final, full-sample student weight containing six components (NCES, 2017a). Extremely large weights are trimmed at the school and student levels to reduce variance. A set of 62 replicate weights is also provided for each student (NCES, 2017b). Replicate weights are used to calculate survey estimate variances using the jackknife repeated replication method (NCES, 2017a). “The method of deriving these weights was aimed at reflecting the features of the sample design appropriately for each sample, so that when the jackknife variance estimation procedure is implemented, approximately unbiased estimates of sampling variance are obtained” (NCES, 2017b).

When scoring math performance, NAEP uses plausible values instead of individual scores. This means that NAEP never actually calculates individual test scores, instead obtaining plausible values by using the responses to each question from a representative sample of students (NCES, 2016). Plausible values therefore estimate how similar students perform. Since every student does not answer every question, these estimates are valuable. In turn, plausible values are a distribution of possible scores. Plausible values, unlike individual scores, provide valid estimates of population effects (NCES, 2016). The 2013 NAEP had 20 plausible values for each subsection of the math NAEP (NAGB, 2013):

- Number properties and operations
- Measurement

- Geometry
- Data analysis, statistics, and probability
- Algebra

There were also 20 composite plausible values, which were used in this study.

Research Design and Data Analysis

This study focused on access to education resources, student effort and self-efficacy, and teacher training and professional development. Therefore, questionnaire items from student demographics (23 items), student affective disposition (10 items), student academic record and school experience (one item), and teacher preparation, credentials, and experiences (96 items) were used (NAEP, n.d.). I selected 23 items related to the focus of the study (Table 2). These 23 items were reduced to three factors that were used as independent variables in a linear regression with the 20 composite plausible values used as the dependent variables.

Table 2

List of NAEP Questionnaire Items Selected as Variables for Study

Participant Type	NAEP Survey Statement
Student	Books in home
Student	Computer in home
Student	Days absent from school last month
Student	Use the internet to learn things about math
Student	Do math at after-school or tutoring programs
Student	Math work is too easy
Student	Like what is done in math class
Student	Can do a good job on math tests
Student	Can do a good job on math assignments
Student	Like math
Student	Math is a favorite subject
Student	Effort on this math test
Student	Importance of success on this math test
Teacher	Professional development in how students learn math

Teacher	Professional development in math theory or applications
Teacher	Professional development in curricular materials in math
Teacher	Professional development in instructional materials in math
Teacher	Professional development in effective use of manipulatives
Teacher	Professional development in methods for assessment in math
Teacher	Professional development in preparing students for district/state assessments
Teacher	Professional development in issues related to ability grouping
Teacher	Professional development in teaching students with diverse backgrounds
Teacher	Professional development in content standards in math

NAEPEX, the toolkit for accessing the NAEP restricted database was used to create a file containing variables from student demographics, student affective disposition, student academic record and school experience, and teacher preparation, credentials, and experiences. Additionally, replicate weights and jackknife data were included in this file. The file was then imported into SPSS Predictive Analytics Software (SPSS) and PCA was performed. While not technically a factor analysis, the uses and outcomes are similar. As a result, researchers often use the term "factor analysis" when using a PCA (Meyers et al., 2017) and, here, the terms are used interchangeably. PCA helps researchers reduce many variables into fewer factors based on commonalities. The PCA yielded three factors. The present study analyzed the descriptives of these variables to assign them names: self-efficacy, effort and access, and teacher training in assessment and instruction. The results of the PCA are detailed in the Results section.

After the factors were created, the SPSS data was imported into AM Statistical Software (AM). AM was designed to perform complex statistical analyses on large amounts of data from assessments (American Institutes for Research [AIR], 2024), thus facilitating analysis of the data set from NAEP, including plausible values. A linear regression model using the 20 composite plausible values was run on AM to determine if there was a significant relationship with any of the three factors. These results are described in Chapter 4.

Reliability and Validity. The fourth-grade NAEP exam has a very large sample size, with about 186,500 students taking the assessment (NAEP, 2013b). The sampling of schools and students is a multi-tiered process that accounts for all 52 jurisdictions and has set criteria for participation (NAEP, 2013b). Participation rates for individual school samples must be 70% or higher to be included in national results. If participation rates fall below 85%, a nonresponse bias analysis is conducted, which determines if the responding school sample is not representative of the population. Participation rates for public schools were 100% and 71% for private schools and, therefore, nonresponse biases were performed for private schools. The results showed that:

> While the original responding school samples may have been somewhat different from the entire sample of eligible schools, including substitute schools and adjusting the sampling weights to account for school nonresponse were partially effective in reducing the potential for nonresponse bias. (NAEP, 2013b).

There were, however, some examined variables that indicate potential bias.

Overall, participation rates for the fourth grade on the 2013 NAEP exam were 97% when including public and private schools. Every state had a participation rate of 95% or higher. As discussed previously, NAEP uses weighting and replicate weights to ensure validity.

Conclusion

The NAEP assessments include a diverse sample of participants from throughout the U.S. The NCES takes many measures to provide accurate and reliable data on the country's performance. Using data from the 2013 grade 4 NAEP math assessment, the next chapter details which variables pertain to this study, how they are turned into factors, and if the factors have a significant relationship with assessment performance.

CHAPTER 4 RESULTS

This chapter reports findings for the data analysis of factors pertaining to the research questions and the 20 composite plausible values from the 2013 grade 4 NAEP math assessment. The results of each factor analysis and the linear regression model are outlined in Tables 4.1 through 4.7 and discussed. Each of the three factors is discussed in terms of their effect on student assessment outcomes.

Results

Factor Analyses

A factor analysis was conducted using the variables from Table 3.1, which were chosen based on the research questions and theoretical framework of the study. A PCA was conducted with all 23 chosen items. A varimax rotation method with Kaiser Normalization was used, with the retention criteria of eigenvalues greater than 1.0. The purpose of the factor analysis was to reduce the variables into a few factors of items with correlating responses (Meyers et al. 2017). A Promax rotation was considered but Meyers et al. (2017) state that the differences are negligible and either choice is valid. The purpose of the rotation is to achieve a simple structure. The lines of best fit that are constructed through the variables are rotated for the purpose of ensuring that lines are not so far away from certain variables that the importance of the distance is magnified. The first line of best fit in factor analysis will always minimize the sum of the squared distances between all variables and, without rotation, this leaves the remaining factors showing possibly less correlation than exists. Factors are rotated until the sum of the squared distances of all factors is minimized (Meyers et al., 2017). Missing values were excluded case-wise, as the sample was large.

The result of the first factor analysis revealed three factors with eigenvalues greater than 1.0 (Table 3). E ach variable loaded for at least one factor using the criteria that factor loadings must exceed 0.30. Some items appeared to load for more than one factor with similar factor loading values. I used theory rooted in education, specific to the theoretical framework of this study, to determine the best fit and run additional factor analyses, which are detailed later in this chapter.

Table 3

Factor Analysis/Principal Components Analysis, All Variables

Rotated Component Matrix[a]

	Component		
NAEP Survey Item	1	2	3
Prof dev-instructional methods for math	0.879		
Prof dev-effective use of manipulatives	0.857		
Prof dev-methods for assessment in math	0.855		
Prof dev-how students learn math	0.846		
Prof dev-math theory or applications	0.818		
Prof dev-curricular materials in math	0.805		
Prof dev-issues related to ability grouping	0.803		
Prof dev-content standards in math	0.798		
Prof dev-teaching math students with diverse backgrounds	0.779		
Prof dev-prep students' district/state assessments	0.719		
Like math		0.839	
Math is a favorite subject		0.816	
Like what is done in math class		0.786	
Can do a good job on math tests		0.704	0.303
Can do a good job on math assignments		0.693	0.361
Math work is too easy		0.607	0.385
Importance of success on this math test		0.464	0.459
Computer in home		0.319	0.797
Use the Internet to learn things about math			0.785
Days absent from school last month			0.695
Do math at after-school or tutoring programs			0.692
Books in home			0.580

Effort on this math test	0.338	0.536

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in five iterations.

Three factors emerged from the initial PCA. The first factor included all ten of the teacher items, and since all of these contained professional development, a single factor was created from these items called "Teacher Professional Development in Assessment and Instruction." This reveals that teachers who receive training in one area tend to receive training in many areas pertaining to education instruction and assessment. The second factor that emerged pertained to one's perception of their math ability (self-efficacy). The third factor pertained to how much effort students put into their work, based on both feelings and availability of people and resources with which to apply effort. Variables with multiple loading greater than 0.30 had large differences, except for "importance of success on this math test." Analysis of the variables and loadings showed that all variables belong with their higher loading variable, except for "importance of success on this math test," because regarding something as important aligned more with the effort put into it than the feelings about the specific subject. While self-efficacy can affect how important a task is seen to be (Bandura, 1986; Koray and Bilgin, 2023), it is not the only influence.

Due to these results from the first PCA, I ran a second PCA with only the items that loaded for and aligned with educational theories for self-efficacy (Table 4). No rotation was performed since only one factor emerged. Six variables made up this factor, which I called "math self-efficacy." Since self-efficacy describes how one feels about their ability (Bandura, 1986; Schunk, 2016), it makes sense that feelings about math correlate with perceived ability in math.

Table 4

Math Self-Efficacy Factor

NAEP Survey Item	Component 1
Like math	0.831
Like what is done in math class	0.816
Math is a favorite subject	0.802
Can do a good job on math assignments	0.791
Can do a good job on math tests	0.790
Math work is too easy	0.734

Extraction method: PCA.

A final PCA was run using the remaining variables that pertained to how much effort students put into their work, based on both feelings and availability of people and resources with which to apply effort (Table 5). No rotation was necessary since only one factor emerged, which was named “effort and access” since it contained items related to physical resources and human capital, as well as the effort that students put into their work.

Table 5

Effort and Access Factor

Component Matrix

NAEP Survey Item	Component 1
Computer in home	0.857
Use the Internet to learn things about math	0.799
Do math at after-school or tutoring program	0.728
Effort on this math test	0.672
Importance of success on this math test	0.662
Days absent from school last month	0.659

Books in home	0.605

Extraction method: PCA.

Plausible Values Regressions

In this study, plausible values regressions were performed using the AM statistical software to determine if any of the three factors in the study significantly impacted achievement on the 2013 fourth-grade NAEP math assessment. Plausible values, as discussed in the Methods section, are not individual scores but a distribution of possible scores. The 20 composite plausible values from the NAEP exam were used to measure overall achievement.

The SPSS file imported from NAEPEX and used for factor reduction was imported into AM. The three factors were selected as the independent variables with the 20 composite plausible values used as the dependent variables. After inputting this data, AM outputs the *F-statistic*, its corresponding *p*-value, R^2, and the root mean square error. AM also outputs the following values for each independent variable and the constant: estimate, standard error, *z*-score, and the *z*-score's associated *p*-value.

Research Question 1. A plausible values regression for each factor was conducted individually to test Research Question 1: Does student self-efficacy about mathematics ability influence success in elementary mathematics? The 20 composite plausible values were used as the dependent variables, with the self-efficacy factor as the independent variable. Self-efficacy impacted achievement on the NAEP assessment based on the AM output (Table 6). With the associate *p*-value of less than 0.001, self-efficacy had a significant effect on assessment scores. Therefore, the null hypothesis for Research Question 1 is rejected. The R^2 value for the test was 0.030, indicating that three percent of the variance in the 2013 NAEP grade 4 math assessment was determined by student self-efficacy toward math.

Table 6

Plausible Values Regression for Self-Efficacy

Parameter Name	Estimate	Standard Error	*z*-Score	$p > \|z\|$
Constant	241.893	0.259	935.739	0.000
Self-Efficacy***	6.163	0.195	31.578	0.000
Root Mean Square Error	29.036			

***$p<0.001$, **$p<0.01$, *$p<0.05$

$R^2 = 0.030$, $F(1, 92) = 997.165$, $p<0.001$

Research Question 2. Next, this researcher conducted a plausible values regression for Research Question 2: Do students' efforts in math and their access to help from materials and people outside of school influence success in elementary mathematics? I again used the 20 composite plausible values for the dependent variables. This time, the effort and access factor was used as the independent variable. The AM software indicated that the effort and access factor did not have a significant effect on the 2013 NAEP grade 4 math assessment (Table 7). With $p=0.284$, the test was not significant. Therefore, the null hypothesis for Research Question 2 is accepted. An R^2 value of 0.000 indicates little to no correlation (Meyers et al., 2017).

Table 7

Plausible Values Regression for Effort and Access

Parameter Name	Estimate	Standard Error	*z*-Score	$p > \|z\|$
Constant	241.592	0.262	923.748	0.000
Effort and Access	0.241	0.225	1.071	0.284
Root Mean Square Error	29.607			

***$p<0.001$, **$p<0.01$, *$p<0.05$

$R^2 = 0.000$, $F(1, 91)=1.14782$, $p=0.286839$

Research Question 3. Next, another plausible values regression was run to answer Research Question 3: Does the professional development that teachers receive influence the mathematics achievement of their students in elementary grades? The professional development in assessment and instruction factor was used as the independent variable, with the 20 composite plausible values once again used as the dependent variables. The independent variable was significant ($p=0.022$) and therefore, the null hypothesis for Research Question 3 is rejected. Although there was a significant p-value, $R^2 = 0.000$, which indicates that despite the statistical significance, there is a low effect size. The statistics from the regression analysis are listed in Table 8.

Table 8

Plausible Values Regression for Professional Development in Assessment and Instruction

Parameter Name	Estimate	Standard Error	z-Score	$p > \|z\|$
Constant	241.678	0.258	938.121	0.000
PD in Assessment and Instruction*	–0.407	0.178	–2.284	0.022
Root Mean Square Error	29.550			

***p<0.001, **p<0.01, *p<0.05

$R^2 = 0.000$, $F(1, 91) = 5.21619$, $p = 0.0247041$

Research Question 4. To determine if all three factors together impacted achievement on the NAEP assessment, I ran a multiple plausible values regression to answer Research Question 4: Do these three elements, in combination, contribute to students' success in elementary mathematics? Three independent variables were used in this regression of each of the three factors. The 20 composite plausible values were used as independent variables. It is important to report the data from the multiple regression analysis, as "most researchers believe that using more than one predictor or potentially explanatory variable can paint a more complete picture of how the world works than is permitted by simple linear regression" (Meyers at al., 2017, p. 157). Each factor showed significance when interacting with math scores in this multiple plausible values regression (all *p*-values <0.05). R^2=0.035, which would indicate a shared variance of 3.5% (Meyers et al., 2017). The null hypothesis is rejected for Research Question 4. The statistics are shown in Table 9.

Table 9: Multiple Plausible Values Regression

Parameter Name	Estimate	Standard Error	*z*-Score	$p > \|z\|$
Constant	241.723	0.255	949.612	0.000
PD in Assessment and Instruction**	–0.475	0.177	–2.683	0.007
Self-Efficacy***	7.208	0.182	39.572	0.000
Effort and Access***	–3.526	0.243	–14.533	0.000
Root Mean Square Error	29.036			

***p<0.001, **p<0.01, *p<0.05

$R^2 = 0.035$, $F(3,89) = 563.905$, $p<0.001$

Summary

The most significant results from this study indicate that the factors play a significant role in determining success in math in grade 4. First, self-efficacy has the greatest effect on student achievement when analyzing a single factor as an independent variable. Second, and more importantly, the multiple plausible values regression showed the most shared variance, which means these three factors work together to influence student achievement. It also indicates that the factors influence each other, which is studied further in Chapter 5.

CHAPTER 5 DISCUSSION

In this chapter, I discuss the implications of the findings pertaining to instruction, training, and educational policy followed by the limitations of the NAEP assessment and the present study. Finally, recommendations for future research are discussed.

Discussion

Implications of the Findings

The NAEP exam and survey include many items and variables, just as there are many variables that affect student achievement. This study aimed to determine how much student achievement can be attributed to student self-efficacy, effort and access, and teachers' professional development. Much research has already been performed on each of these factors individually.

The findings of this study suggest that there is a significant relationship between achievement and self-efficacy. Although there may not be a strong relationship indicated by this study, there are many visible and underlying factors that also play a role in determining student outcomes. Past literature has suggested that self-efficacy has a positive relationship with both academic achievement and emotions such as motivation (Blândul and Bradea, 2022; Yu et al., 2022). Lu et al. (2023) found that motivation may lead to self-efficacy in math and that the environment and culture that a teacher creates can also influence self-efficacy. The present study compared self-efficacy and teachers' professional development to student outcomes. Teacher training in math may give teachers the tools to motivate and generate positive self-efficacy. Self-efficacy had the largest effect on NAEP results when comparing single-factor analyses.

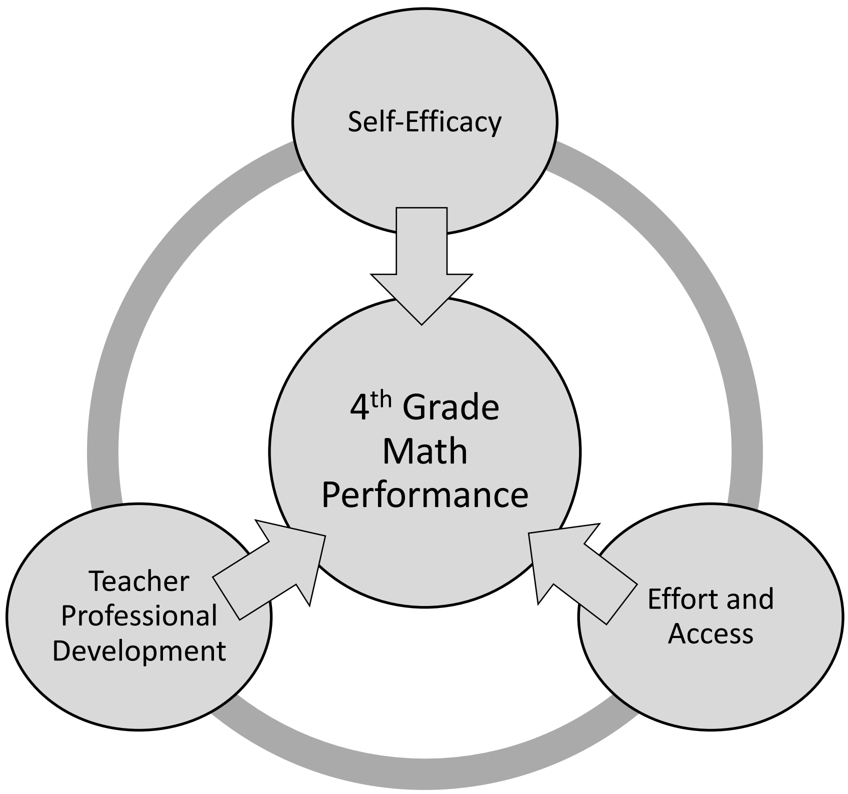
Professional development alone had a significant effect on student achievement on the fourth-grade math NAEP assessment, which is in agreement with prior research. Past studies have correlated professional development to student outcomes at different academic levels and in different academic subjects (Gupta & Guang-Lea, 2020; Shaha et al., 2015; Ekmekci et al., 2019). This study was able to account for many types of professional development but teachers come to professional development with different initial training experiences, different levels of knowledge, and different background experiences (Gupta & Guang-Lea, 2020). When considering the effect in this study, professional development may have had a weak correlation because it does not account for what teachers actually learn or use. These professional development opportunities may even affect the self-efficacy of teachers. Looking at this information through the lens of the theoretical framework, if training affects teacher self-efficacy, it will in turn affect students' achievement. The theoretical framework also points out the importance of adequate training in MKT (Ekmekci et al., 2019).

The multiple regression analysis included all three factors and indicated that there is a significant relationship when multiple independent variables (self-efficacy, effort and access, and professional development in assessment and instruction) are compared to student achievement even though effort and access alone did not have a significant effect on student achievement; this relationship was the strongest of all four regression analyses. The theoretical framework indicates the importance of teacher self-efficacy (Tschannen-Moran et al. 1998) in student achievement. Teacher self-efficacy changes due to professional development and can influence student achievement and self-efficacy.

The present study supports this and suggests that although the three factors in this study did not correlate with each other, they are influencing each other (Figure 2).

Figure 2

The Interrelatedness of Self-Efficacy, Teacher Professional Development, and Effort and Access on Fourth Grade Math Performance



Each factor in this study influences and is influenced by the other two; together, they all affect math performance.

The implications of this study include lessons for leaders in the 21st century. Since self-efficacy is domain-specific (Artino, 2012) and pedagogical and content knowledge are important for teaching (Ball et al., 2008; Hill et al., 2005), school administrators must use this information to determine when to departmentalize schools. Elementary teachers who teach every subject must become masters of content and pedagogy in multiple domains, attend professional development for multiple subjects, and learn how to grade and interpret data; in addition to the technological and social-emotional requirements of teaching, this leaves little time to perform so many tasks. This is especially true in the U.S. where an above-average percentage of a teacher's day is spent on instructing students (OECD, 2023), resulting in less time for planning and training. Departmentalizing allows teachers more time to become masters of their domain by focusing on one subject rather than many.

Limitations

The fourth-grade NAEP mathematics assessment has limitations. NCES (2022) cautions that there are many socioeconomic and educational factors that may impact performance. As a result, it may not be valid to attribute performance to one or few variables, such as whether students attend public or private schools. NCES also asserts that even when relationships exist between achievement and a variable, it does not reveal the underlying cause, which could be a different NAEP variable or an unmeasured variable.

Unmeasured variables include the number of days students are late, student days absent beyond the last month, teacher attendance, or any information on teacher MKT. As a result, "the results are most useful when they are considered in combination with other knowledge about the student population and the educational system, such as trends in instruction, changes in the school-age population, and societal demands and expectations." (NCES, 2022). The NAEP is also a national assessment in the U.S. and may not apply to other countries of different sizes, cultures, and locations.

The present research study also has limitations. Since it uses regression analyses, it has some of the same limitations as the NAEP itself: relationships do not identify underlying causes, and other underlying variables may be influencing the results. This research focused only on the fourth grade, so it may not be relevant to other grades, especially beyond elementary school. Additionally, although the null hypotheses were rejected for Research Questions 1, 3, and 4, the effect sizes are relatively small. With the highest R^2 value of 0.035 coming from the multiple regression analysis (Research Question 4), there is a statistically significant yet weak relationship. This is due to the relatively large sample size, meaning that a smaller correlation is needed to achieve significance (Meyers et al., 2017). A relationship exists but with $R^2<0.01$, the relationship is considered weak (Cohen, 1988).

Recommendations

This study focused on fourth-grade results on the math NAEP. NAEP assessments are also given in grades 8 and 12. A similar study could be completed using results from the upper-grade NAEP data to see how the same factors affect children of different ages. This study also focused on teachers' professional development. While the category of development was provided, more details could be provided about exactly what the teachers learned in this training. A qualitative study may bring this to light. Qualitative research may also discover more about how self-efficacy, effort and access, and teachers' professional development interact.

Effort and access rely on factors that are often out of a child's control because they are provided by parents, schools, or other providers. The present study examined what the students had access to but not how or why. Researchers could investigate how students obtain these resources and which types of students are likely to have them. Since this study indicates that self-efficacy, effort and access, and teachers' professional development are linked, NAEP should consider adding path analyses to the AM statistical software so that future research can determine the strength and directions of the relationships, which will help determine the causes and effects of each factor on each of the others by revealing the directions and strengths. NAEP should also add questions to the teacher questionnaire that assess the level of MKT of each teacher so researchers can include this in future studies.

This study was performed using data from the U.S. While it may be generalized to similar areas, researchers should examine educational systems in other countries, both similar and dissimilar to the U.S. Data from national assessments in other nations can be used and international comparisons can also be done using data from international assessments, such as PISA.

Schools, policymakers, and other stakeholders should take the information from this study into account when considering the education of elementary school students. Additionally, the types and amount of training that teachers receive can be considered for both current teachers and teachers-in-training. If self-efficacy influences achievement, it should be part of the conversation when discussing successful or struggling students. Schools may even want to implement programs to increase self-efficacy. Lastly, access for students continues to expand as technology advances. The potential positive and negative impacts of this should be closely monitored.

APPENDIX A IRB APPROVAL MEMO

Date: 3-24-2024

IRB #: IRB-FY2024-183
Title: Self-Efficacy of Fourth-Graders: Changes, Accuracy, and Effects on Performance
Creation Date: 1-11-2024
End Date:
Status: Approved
Principal Investigator: Steven Borst
Review Board: St John's University Institutional Review Board
Sponsor:

Study History

Submission Type Initial	Review Type Exempt	Decision Exempt

Key Study Contacts

Member James Campbell	Role Co-Principal Investigator	Contact campbelj@stjohns.edu
Member Steven Borst	Role Principal Investigator	Contact steven.borst08@stjohns.edu
Member Steven Borst	Role Primary Contact	Contact steven.borst08@stjohns.edu

APPENDIX B RESEARCH ETHICS TRAINING CERTIFICATE

fhi360

THE SCIENCE OF IMPROVING LIVES

FHI 360

certifies that

Steven Borst

has completed the

RESEARCH ETHICS TRAINING CURRICULUM

February 12, 2019

REFERENCES

Adnot, M., Dee, T., Katz, V., & Wyckoff, J. (2017). Teacher turnover, teacher quality, and student achievement in DCPS. *Educational Evaluation and Policy Analysis, 31*(1), 54-76.

Akkus, M. (2016). The common core state standards for mathematics. *International Journal of Research in Education and Science (IJRES), 2*(1), 49-54.

American Institutes for Research (2024). What is AM Statistical Software? https://am.air.org/What-is-AM-Statistical-Software

Artino A.R. Jr. (2012). Academic self-efficacy: From educational theory to instructional practice. *Perspectives on Medical Education, 1*(2), 76-85.

Ball, D.L. (1990). The mathematical understandings that prospective teachers bring to teacher education. *The Elementary School Journal, 90*(4), 449-466.

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing math for teaching: Who knows math well enough to teach third grade, and how can we decide? *American Educator, Fall*, 14-46.

Ball, D. L., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education*, *59*(5), 389-407.

Blândul, V. C., & Bradea, A. (2022). The interdependence between perceived self-efficacy and self-assessment skills of academic progress in students. *Problems of Education in the 21st Century, 80*(2), 289-303.

Bruner, J. (1960). *The Process of Education.* Harvard University Press.

Burns, M. (2013). Go figure: Math and the Common Core. *Educational Leadership, 70*(4), 42-46.

Burton, M. (2012). What is math? Exploring the perception of elementary pre-service teachers. *Issues in the Undergraduate Math Preparation of School Teachers, 5,* 1-17.

Campbell, P. F., Nishio, M., Smith, T. M., Clark, L. M., Conant, L. D., Rust, A. H., DePiper, J. N., Cueto, S., Leon, J., Sorto, A. M., & Miranda, A. (2017). Teachers' pedagogical content knowledge and math achievement of students in Peru. *Educational Studies in Math, 94*(3), 329-345.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum.

Ekmekci, A., Corkin, D. M., & Fan, W. (2019). A multilevel analysis of the impact of teachers' beliefs and mathematical knowledge for teaching on students' mathematics achievement. *Australian Journal of Teacher Education, 44*(12), 57-80.

Gibson, S. & Dembo, M. H. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*(4), 569-582.

Gupta, A. & Guang-Lea, L. (2020) The effects of a site-based teacher professional development program on student learning. *International Electronic Journal of Elementary Education, 12*(5), 417-428.

Guskey, T. R. (1982). Differences in teachers' perceptions of personal control of positive versus negative student learning outcomes. *Contemporary Educational Psychology, 7*(1), 70-80.

Guskey, T. R. & Passaro, P. D. (1994). Teacher efficacy: A study of construct dimensions. *American Educational Research Journal, 31*(3), 627-643.

Hart, L. C., Oesterle, S., & Swars, S. L. (2013). The juxtaposition of instructor and student perspectives in math courses for elementary teachers. *Educational Studies in Math, 83*(3), 429-451.

Hiebert, J., Berk, D., Miller, E., Gallivan, H., & Meikle, E. (2019). Relationships between opportunity to learn math in teacher preparation and graduates' knowledge for teaching math. *Journal for Research in Math Education, 50*(1), 23-50.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371-406.

House, J. D. (2009). Elementary school mathematics instruction and achievement of fourth-grade students in Japan: Findings from the TIMSS 2007 assessment. *Education, 130*(2), 301-307.

Izsák, A., Jacobson, E., & Bradshaw, L. (2019). Surveying middle-grades teachers' reasoning about fraction arithmetic in terms of measured quantities. *Journal for Research in Math Education, 50*(2), 156-195.

Lu, H., Chen, X., & Qi, C. Which is more predictive: Domain- or task-specific self-efficacy in teaching and outcomes*? British Journal of Educational Psychology*, 93(1), 283–298

Ma, L. (1999). *Knowing and Teaching Elementary Math: Teachers' Understanding of Fundamental Math in China and the United States.* Lawrence Erlbaum Associates.

Mewborn, D. S. (1999). Thinking among preservice elementary math teachers. *Journal for Research in Math Education, 30*(3), 316-341.

Meyers, L.S., Gamst, G., & Guarino, A.J. (2017). *Applied Multivariate Research: Design and Interpretation* (3rd ed). Sage.

Moliner, L., Alegre, F., & Lorenzo-Valentín, G. (2022). Peer tutoring and math digital tools: A promising combination in middle School. *Mathematics*, *10*, 2360.

Mullens, J. E., Murnane, R. J., & Willet, J. B. (1996). The contribution of training and subject matter knowledge to teaching effectiveness: A multilevel analysis of longitudinal evidence from Belize. *Comparative Education Review, 40*(2), 139-157.

Muñez, D., Bull, R., & Lee, K. (2021). Socioeconomic status, home mathematics environment and math achievement in kindergarten: A mediation analysis. *Developmental Science, 24*, e13135.

NAEP (n.d.) NAEP Data Explorer. https://www.nationsreportcard.gov/ndecore/xplore/NDE

NAEP (2013a). *2013 Mathematics Assessment Report Card: Summary Data Tables for National and State Sample Sizes, Participation Rates, and Proportions of SD and ELL Students Identified.* https://www.nationsreportcard.gov/reading_math_2013/files/Tech_Appendix_Math.pdf

NAEP (2013b). About the 2013 assessments. https://www.nationsreportcard.gov/reading_math_2013/#/about#contacts

NAEP (2019). *NAEP Math: National Average Scores*. The Nation's Report Card: https://www.nationsreportcard.gov/mathematics?grade=4

NAGB (2013). Mathematics Framework for the 2013 National Assessment of

Educational Progress.
https://www.nagb.gov/content/dam/nagb/en/documents/publications/frameworks/mathematics/2013-mathematics-framework.pdf air

NCES (n.d.a). About NCES. https://nces.ed.gov/about/

NCES (2016). *Plausible Values Versus Individual Scores.* https://nces.ed.gov/nationsreportcard/tdw/analysis/est_pv_individual.aspx

NCES (2017a). *Weighting Procedures for the 2013 Assessment.* https://nces.ed.gov/nationsreportcard/tdw/weighting/2013/naep_assessment_weighting_procedures.aspx

NCES (2017b). *Computation of Replicate Weights for the 2013 Assessment.* https://nces.ed.gov/nationsreportcard/tdw/weighting/2013/computation_of_replicate_weights_for_the_2013_assessment.aspx

NCES (2019). *An Overview of NAEP.* https://nces.ed.gov/nationsreportcard/subject/about/pdf/naep_overview_brochure_2021.pdf

NCES. (2024). National Assessment of Educational Progress. https://nces.ed.gov/nationsreportcard/

Newton, K. J., Leonard, J., Evans, B. R., & Eastburn, J. A. (2012). Preservice elementary teachers' math content knowledge and teacher efficacy. *School Science and Math, 112*(5), 289-299.

OECD (2019). *PISA 2018 Results (Volume I): What Students Know and Can Do*, PISA, OECD Publishing: https://doi.org/10.1787/5f07c754-en

OECD (2023). *Education at a Glance 2023: OECD Indicators*. OECD Publishing:

https://doi.org/10.1787/e13bef63-en

Schmidt, W.H. & Burroughs, N.A. (2013). How the Common Core boost quality and equality. *Educational Leadership, 70*(4), 54-58

Schulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Schunk, D. H. (2016). *Learning Theories: An Educational Perspective* (7th ed). Pearson.

Shaha, S.H., Glassett, K.F., & Copas, A. (2015). The impact of teacher observations with coordinated professional development on student performance: A 27-state program evaluation. *Journal of College Teacher & Learning, 12*(1), 55-64.

Shone, E. T., Weldemeskel, F. M., & Worku, B. N. (2024). The role of students' mathematics perception and self-efficacy toward their mathematics achievement. Psychology in the Schools, 61, 103–122.

Short, D. S., & McLean, J. F. (2023). The relationship between numerical mapping abilities, maths achievement and socioeconomic status in 4- and 5-year-old children. *British Journal of Educational Psychology, 93*, 641–657

Swars, S. L. (2005). Examining perceptions of math teaching effectiveness among elementary preservice teachers with differing levels of math teacher efficacy. *Journal of Instructional Psychology, 32*(2), 139-147.

Swars, S., Hart, L. C., Smith, S. Z., Smith, M. E., & Tolar, T. (2007). A longitudinal study of elementary pre-service teachers' math beliefs and content knowledge. *School Science and Math, 107*(8), 325-335.

Tschannen-Moran, M., Woolfolk Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*(2), 202-248.

Valentine, K. D. & Bolyard, J. (2019). Lived moments of shift in prospective elementary teachers' mathematical learning. *Journal for Research in Math Education, 50*(4), 436-463.

Yu, J., Huang, C., He, T., Wang, X., & Zhang, L. (2022). Investigating students' emotional self-efficacy profiles and their relations to self-regulation, motivation, and academic performance in online learning contexts: A person-centered approach. *Education and Information Technologies, 27,* 11715-11740

Zhang, F., Jiang, Y., Ming, H., Ren, Y., Wang, L., & Huang, S. (2020). Family socio-economic status and children's academic achievement: The different roles of parental academic involvement and subjective social mobility. *British Journal of Educational Psychology, 90,* 561-579.

Vita

Name	*Steven Borst*
Baccalaureate Degree	*Bachelor of Science,* *St. John's University* *Queens, NY* *Major: Childhood Education*
Date Graduated	*May 2013*
Other Degrees and Certifications	*Master of Science* *Hunter College* *New York, NY* *Major: Childhood Education with a Specialization in Science, Technology, Engineering, and Mathematics (STEM)*
Date Graduated	*May 2015*