Student teachers and inquiry-based mathematics instruction: The impact of efficacy, autonomy, and cooperating teacher implementation

by

Meredith Beggs

B.S.E., University of Central Missouri, 2012
M.S.E., University of Central Missouri, 2016

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF EDUCATION

Department of Curriculum and Instruction
College of Education

KANSAS STATE UNIVERSITY
Manhattan, Kansas

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Abstract

Guided by Bandura's (1989) social cognitive theory, this study examined the relationship between elementary student teachers self-reported implementation of inquiry-based math instruction and four independent variables. The independent variables included student teachers perceived instructional autonomy, personal math teaching efficacy, outcome expectancy, and student teachers' reporting of their cooperating teachers' implementation of inquiry-based instruction. The study used a cross-sectional survey design to collect data from n=130 elementary student teachers using a researcher-developed questionnaire consisting of five subscales to measure each of the variables. Results of multiple regression analysis show that cooperating teacher implementation of inquiry-based mathematics instruction was the strongest predictor of student teachers' implementation of this instructional practice. Findings from this study emphasize the need to develop strong partnerships between educator preparation programs and partner school districts and to intentionally place student teachers in classrooms that demonstrate best practices in math instruction. Additionally, school districts may use the results to emphasize professional development opportunities in mathematics to promote effective practices in cooperating teachers who will eventually influence the practices of novice teachers.

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Preface

As I reflect on my earliest math experiences in a K-12 public education setting, my memories recall the teacher at the front of the room walking us through how to solve a problem. I remember frantically taking notes in my math journal so that I would be prepared for the practice problems in class and eventually the numerous equations assigned for homework. The expectation to discuss mathematics during class was limited to sharing our answers or, at the very most, the exact steps we took through the procedure that the teacher previously modeled. If the goal was to arrive at a correct answer, then I excelled in this type of environment. I paid attention and I mimicked the steps, often successfully. In my mind, this was what math was all about–following steps precisely and checking your work to be sure you arrived at the correct answer.

After deciding to become an elementary teacher, I experienced limited coursework in mathematics pedagogy and the practices that I observed in my field placements aligned quite closely to my own math experiences. It was not until I pursued my master's degree in an Elementary Mathematics Specialist program that my view of math and how to teach it shifted to a more inquiry-based approach. I realized that math was not simply about finding correct answers. It was about relationships and problem solving. It required a deeper understanding and an ability to communicate effectively with others. My philosophy shifted toward a constructivist ideology that was solidified as my students experienced "aha" moments when I taught them in a more conceptual way. The program changed me as a teacher.

My journey eventually brought me the opportunity to teach math content and pedagogy to preservice elementary teachers. However, with each new group of students the stories that they told about their own math experiences mirrored my own story in so many ways. It makes me *wonder why the cycle of traditional teaching is so difficult to break. It makes me curious about the factors that could support new teachers in implementing inquiry-based methods with their own students. It brings me to this study where I hope the results can help inform our preparation of new teachers in ways that align with best practices.*

Chapter 1 - Introduction

In the United States (U.S.), educator preparation programs (EPP) are tasked with the important role of preparing effective classroom teachers. Among other things, these programs provide students with courses that focus on content, pedagogy, knowledge of learner development, classroom management, and professional dispositions so that graduates are knowledgeable when it comes to both the standards they are required to teach as well as ways to create experiences that are most conducive to learning. Because teachers report that field experiences are the most beneficial components to teacher preparation programs, many universities have restructured their programs to embed field experiences earlier in the program (AMTE, 2017; CAEP, 2018; Peterson & Williams, 2008; Whitney et al., 2002).

Student teaching is considered the capstone experience for preparing preservice teachers (PST) (Fernandez & Erbilgin, 2009; Wilson et al., 2002). During this time preservice teachers are paired with an experienced teacher at a grade level within their desired certification. The student teacher (ST) is expected to combine knowledge gained from their EPP along with requirements specific to the district in which they are placed to gain experience as a classroom teacher. The cooperating teacher (CT), along with a university supervisor (US) often assigned by the educator preparation program observe the student teacher as they implement lessons and provide feedback on multiple aspects of the teaching process.

Student teachers face a unique challenge as they balance expectations from their EPP while also navigating the requirements of their student teaching classroom. As they teach alongside their CT, STs are responsible for adhering to the expectations of their CT, building principal, and district policies. Simultaneously, they are still enrolled through their EPP and are expected to complete field-embedded assignments or portfolios. The divergence of these two institutions can create challenges when philosophies and goals of the teacher preparation program differ with what STs experience in their field placements (CAEP, 2018; Feiman-Nemser, 2001; Wilson et al., 2002; Fernandez & Erbilgin, 2009). This is especially prevalent in the field of mathematics education as competing ideas of what it means to *do* and *teach* mathematics are often encountered by preservice teachers.

Elementary PSTs enter mathematics content and pedagogy courses with a variety of experiences that shape their views of mathematics, how the content is learned, and how it should be taught. As PSTs describe what some may consider a "traditional" math experience, they come to their education classes with the belief that math is about following steps to arrive at a correct answer (Kang, 2022). Many believe students are most successful with math when the teacher clearly models and provides multiple examples of correct computations (Ball, 1990; Benken & Brown, 2008; Fonseca, 2021). This emphasis on procedures contrasts with the National Council of Teachers of Mathematics (NCTM) definition of a rigorous mathematics program, requiring conceptual understanding, procedural fluency, and application (NCTM, 2014). Many preservice elementary teachers come from a K-12 program in their own experiences with a heavy emphasis on procedures and very little foundation of conceptual understanding or application (AMTE, 2017; Ball 1990; Benken & Brown, 2008; Kang, 2022).

Contrary to their early mathematical experiences, PSTs find themselves in education courses that often deconstruct their very idea of what mathematics really means (Cassel & Vincent, 2011; Fonseca, 2021). In 2017, the Association of Mathematics Teacher Educators (AMTE) in collaboration with mathematicians and teacher educators across the country, published Standards for Preparing Teachers of Mathematics (SPTM) that outline what "well-prepared beginning mathematics teachers need to know and be able to do upon completion of a certification or licensing program and the characteristics such programs must have to support teachers' development" (p. xxi). The SPTM are organized under two categories: (1) candidate knowledge, skills and dispositions and (2) program characteristics to develop candidate knowledge, skills and dispositions (AMTE, 2017). Additionally, the Council for the Accreditation of Educator Preparation (CAEP) standards, drawing on research in education, are used to evaluate educator preparation programs. Contrary to traditional teaching approaches that focus on procedures and memorization, the SPTM and CAEP standards promote mathematical practices that align with inquiry-based mathematics instruction (IBMI), ensuring PSTs are well-prepared to teach in ways that promote conceptual understanding, problem solving and student engagement.

As EPP instructors implement the recommendations and action steps outlined in the AMTE (2017) and CAEP (2018) standards, preservice elementary teachers often find themselves relearning elementary math ideas (Fonseca, 2021). It seems likely that this relearning causes them to simultaneously reshape their definition of what it means to "do math" as well as reflect on their own changing ideas of themselves in the context of mathematics and a future teacher of mathematics. As EPPs promote inquiry-based practices for teaching mathematics, PSTs are often simultaneously enrolled in a practicum or field component where they spend time in an elementary classroom observing a variety of teaching strategies. Unfortunately, the approach to math instruction in many of these placements fails to align with inquiry-based practices promoted by EPPs (Frykholm, 1996; Harper & Daane, 1998; Ronfeldt & Grossman, 2008).

Mathematics teacher educators have an important role in promoting NCTM's vision and goals for mathematics instruction in the U.S. by preparing teachers who "understand the big ideas of mathematics" and can support students in tackling complex problems from multiple angles (NCTM, 2000, p. 17). While AMTE provides a framework for how to best prepare math teachers in meeting these goals, the reality of implementing the recommendations is challenging. The complexity arises from PST's traditional educational experiences, combined with their field observations of instructional approaches that often contradict AMTE and CAEP standards and recommendations. When their experiences in elementary schools as both students and as PSTs promote traditional teaching, it can be difficult for EPPs to break the cycle and teach using inquiry-based practices.

Social Cognitive Theory as a Framework for Instructional Methods

If EPPs hope to promote instructional practices that align with CAEP, AMTE and NCTM standards, then it is important to consider how behavior is influenced. Bandura's (1989) Social Cognitive Theory (SCT) will be used to explore the complexity of how behavior, in this case mathematics teaching, is influenced by both personal and environmental factors. Bandura (1989) argues that many theories about human behavior focus on either "environmental influences or by internal dispositions" (p. 2). However, Social Cognitive Theory states that behavior includes the relationship between personal determinants, behavioral determinants, and environmental determinants (Bandura, 2012). In other words, human behavior is complex and can be influenced in multiple directions by multiple variables, known as reciprocal determinism. In the context of preparing elementary mathematics teachers, we can see personal determinants in a student teacher's beliefs, efficacy, personal experiences, and attitudes. PSTs are also influenced by environmental factors such as their educator preparation program, instructional practices implemented by cooperating teachers, expectations from others in the field, district-provided curriculum, and educational policy among many. The complex interactions between personal, environmental and behavioral factors influence how these future teachers choose to implement mathematics instruction.

Bandura (2000) notes that humans tend to engage in behavior that they anticipate will lead to positive outcomes and avoid those behaviors that might bring about negative consequences. This is evident in how preservice teachers navigate assignments in coursework, following guidelines that they hope will lead to high grades or achievement (Delgado, 2019). It can be seen in their interactions with their cooperating teacher during the student teaching experience where their level of autonomy could dictate the use of a new instructional approach based on whether they believe it would be praised or criticized by their cooperating teacher. If a preservice teacher views struggle as a sign of failure in their teaching, then they may be less likely to implement problem solving tasks that require students to think deeply and persevere.

A major component of Social Cognitive Theory involves a person's self-efficacy, or their belief in their capabilities. Bandura (2012) outlines four ways that self-efficacy is developed: mastery experiences, social modeling, social persuasion, and physical and emotional states. Each of these components can be examined as preservice teachers develop the skills necessary to be successful mathematics educators. Mastery experiences may occur through lesson design in coursework or implementation in fieldwork. Of course, the type of feedback the teacher candidate receives, or the social persuasion, can influence whether they perceive an experience as "mastery." Social modeling is often evident through modeling by university instructors but is more notable in cooperating teachers who may or may not successfully model inquiry-based teaching methods in their classrooms. Preservice teachers may learn behaviors through these vicarious experiences. Physical and emotional states may dictate whether preservice teachers are willing to teach in ways that are often contrary to their own traditional experiences in K-12 mathematics classrooms. These components are critical to understanding the complex interactions at work during the student teaching experience.

Significance of the Problem

EPPs strive to provide preservice elementary teachers with knowledge and approaches for teaching mathematics that is rooted in research and best practices. Reform in mathematics education has been a topic of conversation for decades, but the change has been slow. If practices are not changing, then what factors are causing student teachers to use traditional teaching approaches in mathematics even though their preparation program has taught them otherwise? Furthermore, are the mathematics content and pedagogy courses provided in the undergraduate programs having any impact on the preservice teachers as they transition from their EPP to the elementary classroom?

Field experiences prior to the traditional student teaching semester are becoming more common in EPPs. In the past, PSTs may not apply instructional strategies in a classroom until their final student teaching semester. However, EPPs, in accordance with AMTE's (2017) recommendations, are creating opportunities for PSTs to engage in elementary classrooms as early as their freshman or sophomore year. This means they are observing CTs implementing math instruction more frequently, thus shaping their view of teaching and learning mathematics.

It is important to understand how factors such as student teachers' inquiry-based math teaching efficacy (composed of personal teaching efficacy and outcome expectancy), perceived instructional autonomy, and cooperating teacher implementation of inquiry-based math instruction (IBMI) relate to the slow change in math teaching practices. By examining the strength of the relationship between the four independent variables (considering both components of teaching efficacy) and the degree to which student teachers report using IBMI, the study can highlight factors that may be most influential in creating change. If personal factors such as personal math teaching efficacy or outcome expectancy show a strong relationship with the implementation of IBMI, then EPPs can focus on ways to build the qualities that lead to high teaching efficacy in teacher candidates throughout their programs. If environmental factors such as CT implementation of IBMI and perceived instructional autonomy show stronger relationships to inquiry-based instruction, then EPPs will need to be more strategic with field placements since STs may be more strongly influenced by their cooperating teacher than the skills and philosophy being developed in the EPP. This would indicate a need for stronger partnerships and a bridge between theory and practice with partner districts. The information from this study can inform the partnerships EPPs build with districts to provide coherence and break the cycle of traditional teaching methods.

Study Purpose and Research Questions

The purpose of this research is to explore possible relationships between personal factors and environmental factors that may influence whether elementary student teachers report using an inquiry-based approach when teaching mathematics. Personal factors include personal teaching efficacy and outcome expectancy specific to inquiry-based instruction. Environmental factors include the student teachers' reporting of their cooperating teachers' implementation of IBMI as well as student teachers perceived instructional autonomy. The specific research questions are as follows:

- To what extent is elementary student teachers' implementation of inquiry-based mathematics instruction associated with their perceptions of math teaching efficacy, instructional autonomy, and cooperating teachers' implementation of inquiry-based instruction?

- To what extent does the relationship between elementary student teachers' implementation of inquiry-based mathematics instruction and math teaching efficacy differ by their perceptions of instructional autonomy and cooperating teachers' implementation of inquiry-based instruction?

Study Overview

The study involved elementary and early childhood student teachers from EPPs at midwestern universities. Participants completed a minimum of twelve weeks of field work during their student teaching semester where they taught under the supervision of a cooperating teacher. Teaching mathematics as part of their student teaching responsibilities in kindergarten through fifth grade classrooms was a requirement for participation in the study.

In the final weeks of their student teaching semester, participants were invited to complete a questionnaire that included five subscales. The dependent variable measured the extent to which the student teacher implemented inquiry-based math instruction during their student teaching semester, using a self-reporting scale. The independent variables included ST's perceived instructional autonomy, personal teaching efficacy, outcome expectancy, and the ST's reporting of their cooperating teachers' implementation of IBMI.

After data collection, Statistical Package for Social Sciences (SPSS) was used to conduct several statistical analyses. Bivariate and multivariate correlation analyses were used to test relationships among the variables. Multiple regression analysis was conducted to test how much variance in the dependent variable was due to each of the independent variables. A moderating regression model was used to determine whether the relationship between math teaching efficacy and implementation of IBMI differed by cooperating teacher implementation or perceived instructional autonomy.

Boundaries of the study: Limitations and Delimitations

Limitations

Due to the strategic selection of midwestern educator preparation programs that meet specific criteria, the results of the study may not be generalizable to the larger population outside of the midwestern region of the United States. While the goal of math methods courses is to integrate “mathematics, practices for teaching mathematics, knowledge of students as learners, and the social contexts of mathematics teaching and learning” (AMTE, 2017; p.26), participants from each university will have differing experiences in these methods courses based on curriculum and the instructional approaches of their EPP faculty. Participants’ experiences in field placements prior to student teaching will vary in the number of hours required by their program as well as the type of placements (urban, suburban, rural) experienced.

In addition, the researcher anticipated that most of the participants would likely be female, thus limiting the male perspective and experience in the study. Because about 19% of the participants were students that the researcher had in courses prior to the study, participants may have perceived desirable answers based on their relationship with the researcher, leading to response bias (Dillman et al., 2014). The student teachers reported on methods that they saw their cooperating teacher using, so these could be limited to the lessons that the student teacher was present to see and may not fully represent the cooperating teacher’s instructional style. In addition, if given the survey themselves, the cooperating teachers could report their teaching methods differently than the student teachers perceive them. There are many factors that could influence why student teachers use certain approaches for teaching math such as mandated curriculum, access to resources, personal beliefs, etc., so causation is not possible in this study.

Delimitations

The participants submitted questionnaires anonymously so that responses cannot be linked to themselves or their assigned cooperating teacher. Submissions from participants who did not meet the criteria (student teaching under the supervision of a cooperating teacher in a K-5 classroom that includes math instruction) were not included in the study to focus the results on this population.

Positionality Statement

As a math teacher educator, I approach this research with strong beliefs about the value of inquiry-based instruction in mathematics education. These beliefs are grounded in my continuing education and my experiences teaching both elementary students and preservice teachers. Observing "aha" moments and shifts towards more positive mathematics dispositions in my young and adult students has reinforced my commitment to inquiry-based approaches. However, I recognize that these beliefs developed over time through my own professional journey, and that my participants, preservice elementary teachers, are in a different stage in their development and may not share the same perspectives on mathematics instruction.

Because of my role as a math teacher educator and advocate for inquiry-based approaches, I acknowledge the potential for bias in my research. Throughout the research process, I engaged in ongoing reflection to examine my assumptions and took deliberate steps to remain neutral when collecting data, analyzing, results, and interpreting findings.

Definition of terms

Cooperating Teacher (CT): A certified classroom teacher employed by a school district who allows an undergraduate student to observe and/or teach in their classroom

Educator Preparation Program (EPP): Programs designed to prepare K-12 teachers for the education workforce, often embedded in a university

Instructional Autonomy: "…authority to make decisions about content and methods in instructional activities (Kim et al., 2008 p 164).

Inquiry-Based Mathematics Instruction (IBMI): students engage in guided explorations where they actively seek solutions to mathematical problems rather than receiving the information directly from the teacher (Vijayaprabha et al., 2015); often follows you-we-I do (Seely, 2014); focus on multiple representations, problem solving, and mathematical discourse (NCTM, 2000).

Mathematical Knowledge for Teaching (MKT): "the mathematical knowledge needed to carry out the work of teaching mathematics" (Loewenberg-Ball et al., 2008, p 395).

Mathematical Teaching Practices (MTP): These practices provide a research-based framework for guiding and strengthening the teaching and learning of mathematics. When implemented effectively, they are high-leverage, essential, equitable practices; and taken together, they support and promote a deep learning of mathematics. (National Council of Teachers of Mathematics, (2014)

Mathematics Teaching Efficacy: "the teacher's sense of how effectively they can teach mathematics" (Newton et al., 2012).

Preservice Teacher (PST): A student enrolled in a program designed to teach them how to become an effective educator

Questionnaire: "A survey instrument containing the questions in a self-administered survey" (Check & Schutt, 2012).

Standards of Mathematical Practice (SMP): Describes the actions that students should be engaged with in a high-quality mathematics program

Student Teacher (ST): A preservice teacher in their final semester of an educator preparation program where they teach under the supervision of a cooperating or mentor teacher in a classroom setting

Subscale: The set of questions used to measure one variable

Survey Research: "involves the collection of information from a sample of individuals through their response to questions" (Check & Schutt, 2012).

Teacher Autonomy: "a transfer of authority and flexibility towards teachers to improve their teaching practices" (Nihayah et al., 2023, p 55).

Traditional Teaching Approach: characterized as teacher-centered with emphasis placed on following procedures to arrive at correct answers (Vijayaprabha et al., 2015); often follows I-we-you do (Seely, 2014).

Summary

It is well-established that there is a disconnect between instructional approaches supported in educator preparation programs and the practices that student teachers observe and experience in their field placements (CAEP, 2018; Frykholm, 1996; Harper & Daane, 1998; Ronfeldt & Grossman, 2008). While many factors have already been identified that are required for teachers to use inquiry-based practices, this study is necessary to examine more closely the possible relationships between selected variables as well as the strength of those relationships toward inquiry-based math instruction. The study addresses a gap in literature by examining student teachers perceived instructional autonomy, a topic that is not well-established in current research. Additionally, the study contributes to the literature on PST's math teaching efficacy by specifically examining teaching efficacy through the lens of an inquiry-based approach. The goal of the study is to learn which variables, both independently and in combination with one another, lead to greater use of inquiry-based instruction so that math educators and preparation programs might focus their efforts and find ways to narrow the gap between theory and practice.

Chapter 2 - Literature Review

Introduction

The purpose of this literature review is to describe the qualities of effective mathematics instruction and to examine the challenges that educator preparation programs (EPPs) encounter when promoting inquiry-based instruction to preservice teachers (PSTs). Some of these challenges include competing models for teaching math influenced by shifts throughout history, personal experiences in traditional math classrooms, limited content knowledge, low self-efficacy, resistance to shifting paradigms, and limited experiences with inquiry-based models. Despite these obstacles the National Council of Teachers of Mathematics (NCTM) Standards and the Association of Mathematics Teacher Educators (AMTE) provide guidance for navigating some of these challenges. The literature review will make connections among the challenges that exist and the standards and frameworks that currently exist to address them while providing context for the current study.

Brief History of Mathematics Education

To better understand the challenges of preparing PSTs in mathematics education today, it is important to understand the history of mathematics education in the United States. Competing ideas were debated in the early 1900s as theorists argued about how learning occurs. Early behaviorist theorists believed that learning mathematics was the result of bonds that were created through repetition and practice (Thorndike, 1921). Others shared ideas about math teaching and learning that focused on making meaning and building conceptual understanding (Brownell, 1934). Later, theorists such as Jean Piaget and Lev Vygotsky built on Brownell's (1934) Meaning Theory as constructivism and social constructivism gained popularity.

Mathematics education experienced many phases over the past century, each emphasizing a different aspect of the subject matter. Walcott and Lambdin (2007) organize these eras into six categories: drill and practice, meaningful arithmetic, new math, back to basics, problem solving, and standards and accountability. With each new phase, the pendulum seems to swing between a focus on drills and procedures and problem solving and conceptual understanding.

Over thirty years ago NCTM (1989) published the Curriculum and Evaluation Standards for School Mathematics. This document specified national standards in mathematics and outlined a vision "on what students in American schools should know and be able to do as a result of their study of school mathematics" (Crosswhite et al., 1989, p. 516). NCTM later released Principles and Standards for School Mathematics (NCTM, 2000), which introduced six guiding principles: equity, curriculum, teaching, learning, assessment, and technology. The guiding principles are depicted in table 2.1 below.

Table 2.1

Guiding Principles for School Mathematics

Guiding Principles for School Mathematics
Teaching and Learning: An excellent mathematics program requires effective teaching that engages students in meaningful learning through individual and collaborative experiences that promote their ability to make sense of mathematical ideas and reason mathematically.
Access and Equity: An excellent mathematics program requires that all students have access to a high-quality mathematics curriculum, effective teaching and learning, high expectations, and the support and resources needed to maximize their learning potential.
Curriculum: An excellent mathematics program includes a curriculum that develops important mathematics along coherent learning progressions and develops connections among areas of mathematical study and between mathematics and the real world.
Tools and Technology: An excellent mathematics program integrates the use of mathematical tools and technology as essential resources to help students learn and make sense of mathematical ideas, reason mathematically, and communicate their mathematical thinking.

Assessment: An excellent mathematics program ensures that assessment is an integral part of instruction, provides evidence of proficiency with important mathematics content and practices, includes a variety of strategies and data sources, and informs feedback to students, instructional decisions, and program improvement.

Professionalism: In an excellent mathematics program, educators hold themselves and their colleagues accountable for the mathematical success of every student and for their personal and collective professional growth toward effective teaching and learning of mathematics.

Note. Adapted from *Principles and Standards for School Mathematics* (2000), by the National Council of Teachers of Mathematics. Copyright 2000 by NCTM.

These guiding principles are reflected in The Common Core State Standards for Mathematics (CCSSM, 2010) which were created to address the quality of mathematics learning and equal opportunity in United States schools (Akkus, 2015). The standards pushed teachers to adapt their teaching practices to promote conceptual understanding, problem solving, and multiple representations in mathematics. NCTM and the CCSSM promoted math instructional practices that valued application, conceptual understanding, and procedural fluency, aiming to provide balance to math programs.

Competing Approaches to Teaching Mathematics: Traditional vs. Inquiry-based

The ways in which teachers implement mathematics instruction varies and have an important impact on how students learn mathematical ideas. Traditional mathematics teaching is usually characterized as teacher-centered with emphasis placed on following procedures to arrive at correct answers, while inquiry-based instruction puts students at the center of the learning, fostering deeper understanding of mathematics (Vijayaprabha et al., 2015). Table 2.2 summarizes key differences between traditional and inquiry-based instruction that will be unpacked in this section.

Table 2.2

Comparison of Traditional and Inquiry-Based Approaches in Mathematics

	Traditional	Inquiry-based
Teacher's Role	Lecturer, teacher-centered	Facilitator, student-centered
Student's Role	Passive learners	Active learners
Content Emphasis	Mastering algorithms, formulas, and procedures through repetitive exercises	Problem-solving and building procedural fluency from conceptual understanding
Type of problems	Expressions and equations	Real-world, open-ended problems
Lesson structure	I do-we do-you do	You do-we do-I do

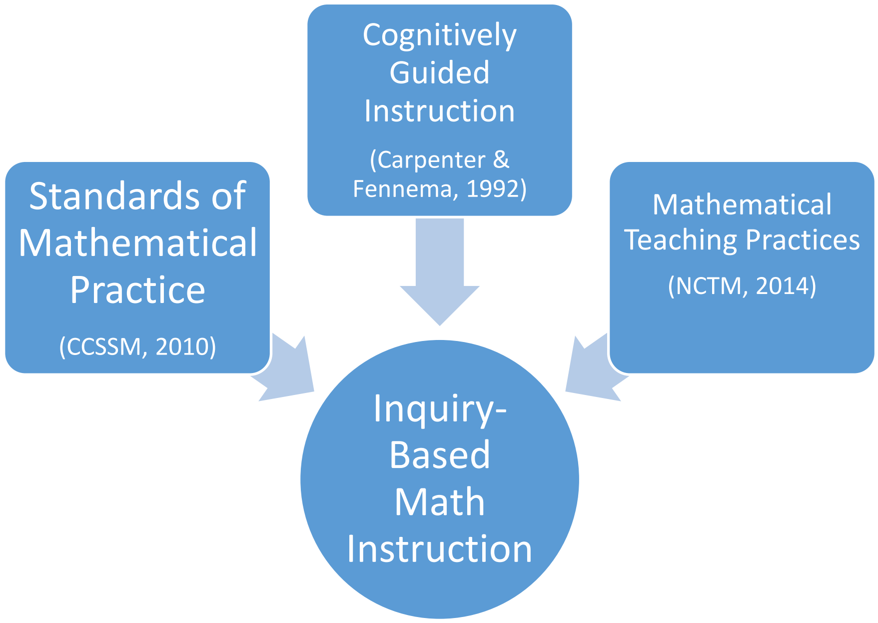
Defining Inquiry-Based Mathematics Instruction

For this literature review, inquiry-based mathematics instruction (IBMI) describes an approach where "rather than receiving information directly from the teacher, students engage in guided explorations where they actively seek solutions to mathematical problems" (Vijayaprabha et al., 2015, p. 99). The approach often follows a you-we-I do structure (Seely, 2014) where students explore a task or problem prior to the teacher modeling a solution pathway. The focus of IBMI is on students using multiple representations, problem solving, and engaging in mathematical discourse (CCSSM, 2010).

IBMI combines ideas from several frameworks, including the Standards for Mathematical Practice (SMP) (CCSSM, 2010), Cognitively Guided Instruction (CGI) (Carpenter & Fennema, 1992), and the Mathematical Teaching Practices (MTP) (NCTM, 2014). Figure 2.1 illustrates the relationship between these three frameworks and IBMI.

Figure 2.1

Three Components of IBMI



The SMPs (table 2.3) draw on NCTM's (2000) five process standards—problem solving, reasoning and proof, communication, connections, and representation—and outline the key behaviors that students should demonstrate in high-quality mathematics classrooms. The SMPs help define IBMI by specifying how students should actively engage in math classrooms.

Table 2.3

Standards for Mathematical Practice

Standard	Description
1	Make sense of problems and persevere in solving them
2	Reason abstractly and quantitatively
3	Construct viable arguments and critique the reasoning of others
4	Model with mathematics
5	Use appropriate tools strategically
6	Attend to precision

7	Look for and make use of structure
8	Look for and express regularity in repeated reasoning

Note. Adapted from "Standards for Mathematical Practices," by National Governor's Association Center for Best Practices & Council of Chief State School Officers, 2010, *Common Core State Standards for Mathematics* (http://www.corestandards.org). In the public domain.

The Mathematical Teaching Practices (MTP) (table 2.4) "represent a core set of high-leverage practices and essential teaching skills necessary to promote deep learning of mathematics" (NCTM, 2014, p 9). These practices help define IBMI by describing the behaviors and skills that teachers use to create opportunities for students to engage in the SMPs.

Table 2.4

Mathematical Teaching Practices

Mathematical Teaching Practices
Establish mathematics goals to focus learning: Effective teaching of mathematics establishes clear goals for the mathematics that students are learning, situates goals within learning progressions, and uses the goals to guide instructional decisions.
Implement tasks that promote reasoning and problem solving: Effective teaching of mathematics engages students in solving and discussing tasks that promote mathematical reasoning and problem solving and allow multiple entry points and varied solution strategies.
Use and connect mathematical representations: Effective teaching of mathematics engages students in making connections among mathematical representations to deepen understanding of mathematics concepts and procedures and as tools for problem solving.
Facilitate meaningful mathematical discourse: Effective teaching of mathematics facilitates discourse among students to build shared understanding of mathematical ideas by analyzing and comparing student approaches and arguments.
Pose purposeful questions: Effective teaching of mathematics uses purposeful questions to assess and advance students' reasoning and sense making about important mathematical ideas and relationships.
Build procedural fluency from conceptual understanding: Effective teaching of mathematics builds fluency with procedures on a foundation of conceptual understanding so

that students, over time, become skillful in using procedures flexibly as they solve contextual and mathematical problems.

Support productive struggle in learning mathematics: Effective teaching of mathematics consistently provides students, individually and collectively, with opportunities and supports to engage in productive struggle as they grapple with mathematical ideas and relationships.

Elicit and use evidence of student thinking: Effective teaching of mathematics uses evidence of student thinking to assess progress toward mathematical understanding and to adjust instruction continually in ways that support and extend learning.

Note. Adapted from *Principles to Actions: Ensuring Mathematical Success for All*, by National Council of Teachers of Mathematics. Copyright 2014 by NCTM.

CGI bridges the student and teacher behaviors by providing a structure where both the SMPs and MTPs can be successfully implemented by teachers. CGI posits that students have intuitive knowledge that they can apply to solve word problems without being given specific procedures to follow first (Carpenter et al., 1996). The approach positions the teacher as a facilitator of learning where the teacher focuses on understanding student thinking so that they can use that understanding to make instructional decisions (AMTE, 2017; Carpenter & Fennema, 1992, Ramaila 2025). This skill is also highlighted in the MTP, “elicit and use evidence of student thinking.” Ramaila (2025) states, “Through open-ended problem solving, formative assessment, and reflective discourse, CGI fosters conceptual understanding, metacognitive awareness, and critical thinking skills” (p. 2). CGI ultimately provides teachers with a framework that allows them to use the MTP and engage students in the SMPs during mathematics instruction.

Teacher and student roles

As theorists debated the importance of drill and memorization (Thorndike, 1921) versus meaning and conceptual understanding (Brownell, 1934), the ideas behind each school of thought were put into practice in mathematics classrooms. The roles of the teacher and students differ greatly among traditional and inquiry-based teaching approaches. Traditional teaching approaches put the teacher at the center of the learning, leading to classroom practices that focus on students' ability to memorize and follow steps and procedures to find an answer (Vijayaprabha et al., 2015). Very little critical thinking is being done by students as the teacher's goal is to deliver the information concisely in a way that is easy for students to follow (Slocum, 1971). Constructivists called for a change in mathematics instruction that put the student at the center of the learning and encouraged teachers to create opportunities for students to build their own understanding based on experiences and interactions with others. Feiman-Nemser (2001) compares the two approaches stating:

> If conventional models emphasize teaching as telling and learning as listening, reform-oriented models call for teachers to do more listening as they elicit student thinking and assess their understanding and for students to do more asking and explaining as they investigate authentic problems and share their solutions (p. 1015).

In other words, the role of teacher and student are flipped in traditional and inquiry-based instructional approaches, putting the student at the center of the learning as the teacher serves as facilitator (Ramaila, 2025). Teachers are responsible for selecting and introducing high-level tasks while students "discuss, explain, and justify their reasoning using varied representations and tools" (AMTE, 2017, p. 16). Students are active participants in the learning process, allowing teachers to plan future instruction based on the students' thinking and problem-solving approaches.

Lesson structure

The timing of direct instruction within a lesson often indicates whether a teacher is using a traditional or inquiry-based approach. A gradual release of responsibility model, often referred to as an I-we-you do approach, starts by having the teacher model a particular skill or algorithm, followed by students practicing the approach with the teacher or peers before having them try the new learning on their own (Saligumba & Tan, 2018). In many ways, we still see these ideas reflected in classrooms today as the teacher models how to solve a problem procedurally, asks students to practice the procedure independently or with peers, then individually assesses them based on the correctness of their answer. This process is often referred to as the explain-practice apply (Van de Walle et al., 2019) or “teaching mathematics by telling” (Smith, 1996, p. 387).

Inquiry-based instruction allows students to explore mathematical tasks and problems prior to the teacher providing direct instruction. Seely (2014) describes this “upside down” approach below:

> *You* (students) will mess around with a task for a while, ideally engaging in some thinking, trying things out, and generally wrestling with or constructively struggling with mathematics arising from the problem; then *We* (students and teacher) will discuss the different approaches students tried, with students explaining, questioning, clarifying and further grappling with the mathematics; finally, *I* (the teacher) will connect this work and the class’s productive discourse around the problem and related mathematical ideas, facilitating the whole process and ensuring that students come away with the intended mathematics learning (p. 90.

She goes onto explain that sometimes student learning may occur through their exploration of the problem and other times the teacher may need to work through an example, but this comes after students have explored first. Van de Walle et al. (2019) describes this process as teaching *through* problem solving rather than teaching *for problem solving* mentioned previously.

Advantages of Inquiry-Based Instruction

Traditional methods for teaching mathematics have significant drawbacks including "a narrow understanding of mathematics, centered on procedural knowledge rather than conceptual insight," limited opportunities to collaborate with peers to develop communication and collaboration skills, and students who become disengaged and even anxious about doing mathematics (Vijayaprabha et al., 2015, p. 96). Van de Walle et al. (2019) warns that focusing on procedures first before applying those procedures to real world problems is common in textbooks and communicates that there is only one way to solve a problem, puts the student in the role of passive learner, assumes all students have necessary prior knowledge, and decreases the chance that students will be willing to attempt a problem without prior instruction.

Vijayaprabha et al. (2015) states that students tend to develop conceptual understanding and critical thinkings skills when using an inquiry-based approach compared to a traditional, teacher-centered approach. Additionally, components of inquiry-based learning directly align with the best practices outlined by NCTM (2000) in their Guiding Principles for School Mathematics. For example, students are given opportunities to make sense of mathematical ideas through collaboration with peers when they attempt problems on their own prior to direct instruction. Furthermore, students are more likely to be engaged in mathematics when given the chance to think about and solve the problem first (Seely, 2014; Ramaila, 2025).

Social Cognitive Theory and Inquiry-Based Mathematics Instruction

From a social cognitive (Bandura, 1989) perspective, IBMI serves as not only a pedagogical approach, but also a behavior to be studied through the context of student teachers. Applying the theory allows one to examine student teachers' instructional methods, or behavior, as a response to personal and environmental factors. While the SMPs and MTPs outline effective mathematics practices, SCT would posit that the level of confidence that student teachers develop for implementing those practices should influence their instructional decisions. Additionally, positive experiences teaching using IBMI would likely increase their confidence with teaching in such a manner, while negative experiences may decrease confidence. Furthermore, student teachers' beliefs about whether IBMI leads to productive outcomes are likely to influence their teaching practice and successful implementation may increase their outcome expectancy. Because the student teacher must function within the physical and philosophical boundaries set by the cooperating teacher, environmental factors would likely include student teachers perceived autonomy from the cooperating teacher and the implementation of IBMI by the cooperating teacher. Their unique environment influences their behavior, in this case, their mathematics teaching approach. According to SCT, these behavioral, personal, and environmental factors should interact in a reciprocal manner, influencing student teachers' instructional approaches.

Preservice Teachers' Traditional K-12 Experiences

Although the National Council of Teachers of Mathematics (NCTM) supports inquiry-based aspects of teaching, traditional teaching continues to be common in K-12 classrooms, often leading to negative consequences. Preservice teachers often report negative feelings when reflecting on their own mathematical experiences, emphasizing the importance of correct answers and rarely making connections between mathematical ideas and procedures (Ball, 1990; Benken & Brown, 2008; Cassel & Vincent, 2011; Swars et al., 2016). Their reported experiences align with a traditional approach to teaching mathematics focusing on facts and rules (Althauser, 2018; AMTE, 2017; Ball, 1990; Benken & Brown, 2008; Fonseca, 2021). Lortie (1975) coined the term "apprenticeship of observation" which refers to the 13,000 hours that students have in direct contact with teachers over their own schooling where they draw conclusions about what it means to be a teacher. The idea that teachers "teach the way they were taught" stems from this idea as Lortie (1975) claims that certain approaches become "tradition and transcends across generations" (p. 63). This idea is seen in EPP courses as PSTs continue to report traditional mathematics experiences despite reform initiatives through the years.

Math Anxiety in Preservice Teachers

Additionally, many preservice teachers report math anxiety stemming from their experiences with either content or a particular teacher in their K-12 mathematics classes leading to low confidence in their own mathematical abilities (AMTE, 2017; Boaler, 2016; Harper & Daane, 1998; Looney et al., 2017; Swars et al., 2006). In fact, traditional teaching approaches can lead to math anxiety as students become disengaged and struggle to keep up with content (Vijayaprabha et al., 2015). Unfortunately, math anxiety has been reported in kids as young as first and second grade (Harper & Daane, 1998; Ramirez et al., 2013). Timed math facts, an instructional approach often seen in traditional math classrooms, is a contributor to math anxiety in young children and an estimated one-third of students experience high levels of stress when given timed tests (Boaler, 2015).

This anxiety seems to be especially prevalent in higher achieving students and girls (Boaler, 2015), which is important when considering that elementary teachers are predominantly female with 89% of public elementary teachers being female during the 2020-2021 school year (National Center for Education Statistics, 2023). Swars et al. (2006) also found that preservice teachers with higher levels of math anxiety focused on memorization and procedures through activities such as timed tests and pop quizzes when describing mathematics, continuing the cycle of traditional teaching.

Fixed Mindset and Negative Dispositions

It is not surprising that math anxiety would lead to negative dispositions toward math given “that mathematics is the subject that people love to hate” (Van de Walle et al., 2019, p. 1). Some of this can be attributed to the fact that people tend to have a fixed mindset when it comes to math, believing that one either inherits the ability to do math or does not (AMTE, 2017; Boaler, 2016), a belief that is seen in elementary education preservice teachers as they enter their preparation programs (Benken & Brown, 2008). This fixed mindset can develop when some students struggle to keep up with their math teacher’s precise explanations while some peers seem to master the content easily (AMTE, 2017; Seely, 2014) or when teachers “publicly praised high-performing students for their right answers and solution speed or referred to certain students as ‘fast’ or ‘smart,’ thus implying that others were slow or not smart” (Haimovitz & Dweck, 2017, p. 6) This belief that no matter one’s efforts, some people are simply hopeless when it comes to learning mathematics can cause individuals to maintain a negative relationship with math for the rest of their lives and, in the context of preservice teachers, the belief can be passed onto young students (Boaler, 2016). AMTE (2017) addresses the importance of beginning teachers to see mathematics as useful and to develop *habits of mind* such as curiosity, risk-taking, and persistence. EPPs are tasked with interrupting this cycle of helplessness in mathematics through the preparation of new generations of teachers.

The Educator Preparation Program: Promoting Change

Given that many teachers draw from traditional K-12 mathematics experiences to shape their understanding of effective teaching, it is important for EPPs to show that alternative, more effective approaches exist. The Council for the Accreditation of Educator Preparation (CAEP, 2018) references key documents from the CCSSM (2010), such as learning trajectories and the SMP. Furthermore, AMTE (2017) encourages preparation programs to utilize the MTPs as a framework (NCTM, 2014) to help preservice teachers effectively implement the SMPs. By adopting these frameworks, EPPs become responsible for redefining mathematics instruction for PSTs.

Developing Mathematical Knowledge for Teaching in Coursework

One way to change PST's view of mathematics teaching and learning from traditional to inquiry-based instruction is for EPPs to develop mathematical knowledge for teaching. According to the SPTM, "Mathematics includes more than learning appropriate content. Effective mathematics teacher preparation programs ensure that candidates are immersed in mathematical practices and processes of reasoning, sense making, and problem solving" (AMTE, 2017, p. 31). Mathematical Knowledge for Teaching (MKT) is defined as "the mathematical knowledge needed to carry out the work of teaching mathematics" (Loewenberg-Ball et al., 2008, p. 395). Loewenberg-Ball and her colleagues point to Schulman's identification of pedagogical content knowledge as a major framework in Mathematics Knowledge for Teaching (Loewenberg-Ball et al., 2008). Schulman (1986) explains that pedagogical content knowledge "goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching" and states that teachers need to know "the most useful forms of representation…powerful analogies, illustrations, examples, explanations, and demonstrations…" (p. 6) for the subject that they teach. In other words, knowing the mathematics content is not enough; effective teachers also know how to most effectively create experiences that will lead to student understanding and achievement. Loewenberg-Ball et al. (2008) encompass these ideas in four components of MKT: common content knowledge, specialized content knowledge, knowledge of content and students, and knowledge of content and teaching.

For many preservice teachers, mathematical knowledge for teaching is first developed in educator preparation programs. CAEP's standards cite the 2010 National Research Council's (NRC) emphasis on the importance of both content and pedagogical knowledge in teacher development. NRC (2010) states that effective mathematics teachers "requires not only mathematical knowledge but also understanding of how mathematics learning develops and of the variation in cognitive approaches to mathematical thinking" (NRC, 2010, p. 4). As EPPs use these standards as a guide for building quality programs, components of MKT are emphasized through the support of these well-established organizations and recommendations.

While the reform movements mentioned previously may be beneficial in reconceptualizing a rigorous and effective math program, the change seems to be slow as preservice teachers continue to enter preparation programs with not only low confidence in their mathematical abilities, but also a view of mathematics that is opposite to the National Council of Teachers of Mathematics Standards (Althauser, 2018; Cassel & Vincent, 2011; Frykholm, 1996; Harper & Daane, 1998; Smith, 1996; Swars et al., 2006). The traditional lens that preservice teachers often bring to college classrooms creates challenges for teacher preparation programs as they attempt to promote an inquiry-based approach to teaching and learning mathematics that focuses on the goals of previous reform movements such as the NCTM Curriculum and Evaluation Standards and the Common Core Standards for Mathematics (Chamberlin, 2013).

This demonstrates a need to develop all components of MKT, since low confidence in mathematical ability indicates low content knowledge and traditional views promote pedagogical approaches contrary to best practices. Therefore, EPPs are tasked with first redefining mathematics teaching and learning since “the images and beliefs that prospective teachers bring to their preservice preparation serve as filters for making sense of the knowledge and experiences they encounter” (Feiman-Nembser, 2001, p. 1016). Math methods courses need to intentionally create opportunities for preservice teachers to recognize and appreciate the process of mathematics by creating experiences that rely on inquiry and problem solving to combat their more traditional experiences (Cassel & Vincent, 2011), and teacher educators must model the constructivist approaches that they promote so that preservice teachers can experience those approaches as learners (AMTE, 2017; Feiman-Nemser, 2001; Kandali, 2017). As teacher educators engage PSTs in an approach that often feels “backwards” to their K-12 experiences, preservice teachers find themselves relearning math content conceptually (Fonseca, 2021).

Findings suggest that the mathematical skills and content knowledge that many preservice teachers bring with them from their previous mathematics classes are not sufficient for them to be able to teach mathematics concepts and procedures meaningfully to their future students (Perry, 2023). This is not surprising given that the National Assessment of Educational Progress (NAEP) given to twelfth grade students in 2019 showed that 40% scored below NAEP basic while only 24% scored at or above NAEP proficiency (The Nation’s Report Card). While some can compute correct answers, few seem to have a conceptual understanding or the ability to explain why a procedure works through a representation or some other conceptual explanation

(Ball 1990; Benken & Brown, 2008; Kang, 2022). Even if PSTs come to EPPs with the ability to solve mathematical problems procedurally, they lack the pedagogical knowledge needed to be an effective math teacher.

Ball (1990) interviewed preservice math teachers as she studied the mathematical understandings that prospective teachers bring to education. One preservice teacher stated:

> I am really worried about teaching something to kids that they don't know. Like long division—I can do it– but I don't know if I could teach it because I don't know if I really know it or know how to word it (p. 449).

This experience demonstrates the complexity of Mathematical Knowledge for Teaching in that a teacher must have a deep understanding of the content beyond following a procedure (Kang, 2022) as well as an understanding of how students learn, what makes topics easy or difficult to understand, and an ability to anticipate misconceptions that students may have (Shulman, 1986). Additionally, the prior experiences and beliefs of this preservice teacher could influence how she would consider teaching the mathematical concept, either through traditional or inquiry-based instructional practices.

Despite the challenges involved in redefining mathematics for preservice teachers, studies show that math courses in educator preparation programs can influence preservice teachers' attitudes, beliefs and knowledge about mathematics (AMTE, 2017; Benken & Brown, 2008; Chamblee et al., 2023; Fonseca, 2021; Kanadlı, 2017). Jansen et al. (2017) found that when observing first year elementary teachers who were asked to teach lessons using a conceptual approach, they were more likely to use mathematical language to support students' sensemaking and use visual representations, both skills emphasized in reform mathematics ideology, when the math topic consisted of content that was covered deeply in their teacher preparation program. This shows that the participants were more successful in teaching conceptually when they had strong content knowledge, highlighting the relationship of content and pedagogical knowledge for teaching mathematics. Furthermore, preservice teachers report that they hoped to teach mathematics using NCTM standards after math methods courses challenged their initial traditional beliefs (Althauser, 2018; Kang, 2016). While many preservice teachers report math anxiety from previous math classes, experiences in EPPs can decrease math anxiety and math teaching anxiety (Boyacı & Erdamar, 2023; Hood, 2023).

However, Chamberlin (2013) conducted a qualitative study using a standards-based approach to teaching mathematics in a methods course for preservice teachers, and while many preservice teachers commented on their appreciation as well as the importance of an inquiry-based approach, ten participants mentioned that the teacher should give direct instruction before allowing students to try similar problems independently and nine participants wanted more teacher explanations or lectures. Preservice teachers who hold traditional views about teaching math are unlikely to teach contrary to those beliefs, therefore it is important for educator preparation programs to provide opportunities for preservice teachers to reflect on their beliefs about mathematics as early in the program as possible (McMinn et al., 2021). If EPPs strive to produce effective mathematics teachers, then they must focus on building MKT through their coursework, despite the preservice teachers' past experiences in traditional math classrooms.

Developing Math Teacher Efficacy in Coursework

As preservice teachers develop MKT through their coursework in EPPs, they also begin to establish teaching efficacy. Mathematics teaching efficacy is defined as "the teacher's sense of how effectively they can teach mathematics" (Newton et al., 2012). Many researchers consider teacher efficacy to be composed of two parts, described by Swars et al. (2006) below:

> The first factor, personal teaching efficacy, represents a teacher's belief in his or her skills and abilities to be an effective teacher. The second factor, teaching outcome expectancy, is a teacher's belief that effective teaching can bring about student learning regardless of external factors… (p. 307).

While the first component, personal teaching efficacy, can be developed through MKT, the second component, teaching outcome expectancy, is linked to PSTs' dispositions toward math. Additionally, their beliefs about student abilities can affect how they view student's success or failure and their instructional decision making (AMTE, 2017). Studies have shown that EPPs can positively influence PST's teaching efficacy (Boyacı & Erdamar 2023; Richardson & Liang, 2008) and that it is important for PST to engage in conversations with university faculty early in their programs to help build math teaching efficacy (Jeffery et al., 2018).

Furthermore, developing MKT is important when considering the relationship between MKT and math teaching efficacy. Studies have concluded different results with one noting that the higher a teacher's MKT, the higher their math teaching efficacy (Alsehehri & Youssef, 2022). Additionally, Bates et al. (2011) found that preservice teachers scored higher on a Basic Skills Test also reported higher self-efficacy. However, the study noted that there is more to MKT than just content knowledge. Furthermore, Austin (2015) found that prospective teachers reported varying levels of math teaching efficacy based on the difficulty of the mathematics concept being taught and that often their reported confidence was higher than their actual math content knowledge, showing a more nuanced understanding of how content knowledge relates to teaching efficacy. Additionally, some studies found that PST reported strong teaching efficacy but did not necessarily feel more confident in their ability to affect student outcomes (Bates et al., 2011; Byrd & Giles, 2023). While the results of the studies vary, it is apparent that MKT relates to math teaching efficacy, even if the extent of that relationship has yet to be fully explained.

The fact that existing literature strongly supports the claim that many elementary preservice teachers bring a negative disposition, low confidence, and high levels of math anxiety with them as they enter educator preparation courses (AMTE, 2017; Ball 1990; Harper & Daane, 1998; Looney et al., 2017) is concerning given the relationship between teaching efficacy and math anxiety. One study found that preservice teachers with the lowest levels of math anxiety had the highest levels of math teacher efficacy (Swars et al., 2006). Furthermore, there is a direct relationship between the teachers' math efficacy and their effectiveness as a teacher (Smith, 1996) and the higher a student's efficacy, the higher their mathematical achievement (Chang, 2015). These previous studies show the importance of math teaching efficacy on student success.

It is worth considering how the reform movement and emphasis on inquiry-based math instruction relates to math teacher efficacy. It is true that most math teaching efficacy scales focus on the teachers' general beliefs about their ability to teach mathematics effectively and their expected outcomes. However, differences would likely be evident between traditional and reform-based teachers when considering their definition and interpretation of "effective mathematics teaching." Smith (1996) argues:

> …the reform of school mathematics content, learning, and teaching undermines the base for teachers' sense of efficacy that teaching by telling provides. Telling mathematics allows teachers to build a sense of efficacy by a) defining a manageable mathematical content that they have studied extensively and b) providing clear prescriptions for what they must do with that content to affect student learning. The current reform removes both supports (p. 388).

While this quote is nearly thirty years old at the time of this literature review, the ideas are still relevant. Althauser (2018) notes that many elementary PSTs thought they would be good math teachers at the beginning of a math methods course, but that their initial understanding of effective math teaching aligned with their own traditional math experiences. There are still opportunities to reconsider mathematics teaching efficacy, focusing on how teachers experience the implementation of inquiry-based teaching ideas into their mathematics instruction and how those changes connect with their feelings of math teaching efficacy in both preservice and in-service teachers.

Field Experiences: Reinforcing or Undermining Inquiry-based Teaching?

Clinical field experiences, a common component to educator preparation programs, often contradict the goals of math educator preparation programs by reflecting the traditional teaching methods that preservice teachers experience during their own K-12 education. Field experiences require preservice teachers to spend time in classrooms where they learn from a cooperating teacher, observe teaching practices, and try teaching approaches promoted by their cooperating teacher and coursework. Because teachers report that field components are the most helpful parts of EPPs, many programs embed these early in their programs (AMTE, 2017; Peterson & Williams, 2008; Whitney et al., 2002). However, the SPTM note that the quality of the field experiences is just as important as the quantity of time (AMTE, 2017). Ultimately, the student teaching experience, where preservice teachers often teach full-time alongside a certified classroom teacher, is often referred to as the capstone experience in an EPP (Fernandez & Erbilgin, 2009).

Existing literature clearly identifies the cooperating teacher as having the strongest influence on student teachers (Anderson, 2009; Frykholm, 1996; Peterson & Williams, 2008;

Whitney et al., 2002; Yee, 1969; Zeichner, 1980). Unfortunately, the instructional strategies used by cooperating teachers do not always support inquiry-based teaching efforts and do not align with methods promoted in EPPs (Frykholm, 1996; Harper & Daane, 1998; Ronfeldt & Grossman, 2008). In fact, one study found that secondary mathematics student teachers felt pressure to implement the NCTM standards from their educator preparation program but did not feel pressure to do so from their cooperating teachers (Frykholm, 1996). Even practicing teachers who report reform-based or student-centered beliefs rarely implement the ideas in their classroom instruction (Simmons et al., 1999; Sun & Shang, 2024). A common challenge to inquiry-based teaching is resistance from teachers due to unfamiliarity or misconceptions about the method (Ramaila, 2025). The reality contrasts with AMTE's (2017) statement, "For candidate to be well prepared in the teaching of mathematics, their programs must provide consistency in what is being taught and modeled in methods courses and field experiences" (p. 37). If there is not a shared vision of mathematics instruction between field experiences and EPPs, then PST receive contradictory information about what is considered effective math teaching.

The misalignment between field experiences and EPPs is even more concerning because many preservice teachers indicate that their teaching mirrors that of their cooperating teacher (Anderson, 2009; Frykholm, 1996). This can leave preservice teachers in a state of cognitive dissonance as they try to make sense of the competing ideas around teaching mathematics (Ronfeldt & Grossman, 2008), causing them to feel unsure about the "right" way to teach math. These studies show that many preservice teachers are likely to observe pedagogical approaches that may not demonstrate best practice, hindering the development of their pedagogical content knowledge and reinforcing their own early experiences with traditional teaching.

Furthermore, practicing elementary teachers rate themselves higher in what they consider practical knowledge than theoretical knowledge (Alshehri & Youssef, 2022), again highlighting the disconnect between theory in EPPs and practices implemented in the field. This is particularly concerning as one study found that preservice teachers tend to justify their teaching choices based on experienced colleagues in the field rather than on educational research (Ferguson & Braten, 2022). If PSTs value the instructional practices of cooperating teachers over the methods promoted in EPP coursework, then it is not surprising that change in mathematics education is slow.

To develop both MKT and math teaching efficacy in field experiences, preservice teachers need opportunities to discuss mathematics planning and reflect on teaching experiences, but many report little support in these areas (Fernandez & Erbilgin, 2009; Haciomeroglu, 2013). One study found that the amount of dialogue around math teaching depends on how invested the cooperating teacher is in mathematics, with more invested teachers spending more time discussing math and how to teach it (Peterson & Williams, 2008). Not only that, but Haciomeroglu (2013) found in a study with elementary student teachers that only 38.6% of cooperating teachers were perceived to instill positive attitudes toward teaching mathematics. This raises concerns about the differing experiences of preservice teachers in their mathematics field components and how the frequency and quality of mathematical dialogue and reflection could impact the development of MKT and teaching efficacy.

While developing the MKT necessary for inquiry-based math instruction presents challenges in field experiences, EPPs can also leverage their partnerships to enhance teacher preparation. For example, Boyd et al. (2009) found that teachers who have experiences planning and implementing lessons, analyzing student work, and conducting other authentic teaching tasks during their educator preparation program show more growth during their first year of teaching. Analyzing student work to understand what students know and identify their misconceptions is one important aspect of building MKT, promoted by the SPTM (AMTE, 2017). This can be carefully developed through coursework assignments connected to field experiences, and programs should scaffold field experiences that allow PSTs to plan, teach, assess, and reflect on effective mathematics instruction (AMTE, 2017).

Positive field experiences can contribute to higher self-efficacy if PSTs have opportunities to observe effective teaching approaches (Kandali, 2017), and preservice teachers are more effective in their own teaching when they are paired with CTs who are more instructionally effective (Ronfeldt et al., 2018). Furthermore, PSTs reported positive changes in elementary students when they taught using conceptual approaches, increasing the PST's self-efficacy (Althauser, 2018). Ultimately, cooperating teachers who are strong in content knowledge, willing to provide feedback, and align their methods with those of the educator preparation program can help contribute to effective field experiences (AMTE, 2017; Miler et al., 2023).

The Challenge of Instructional Autonomy in Student Teaching

While the impact of the cooperating teacher is well-established, the role of the cooperating teacher is one that is complex and varies with individual leadership approaches (Wilson et al., 2002). Weasmer & Woods (2003) found that cooperating teachers most often referred to themselves as models, mentors, and guides. Student teachers report specific feedback, sharing of ideas, and freedom to try new ideas as important characteristics of an effective cooperating teacher (Connor & Killmer, 1995; Sayeski & Paulsen, 2012). Freedom to try new ideas is an important component of autonomy as evidenced by preservice teachers' association of autonomy with independence, freedom, responsibility, and power or control (Delgado, 2019).

Ulas & Aksu (2015) identified three areas of teacher autonomy: autonomy in instructional planning and implementation, autonomy in professional development, and autonomy in determining the framework of the curriculum. In the context of student teachers, autonomy in instructional planning and implementation is most relevant. Instructional autonomy is defined as the "…authority to make decisions about content and methods in instructional activities" (Kim et al., 2008 p. 164).

It is likely that student teachers' instructional autonomy is influenced by the mentoring approach of their cooperating teacher, and "student teachers who reported better quality cooperating teachers and more autonomy over instructional decisions felt better prepared to teach and had stronger teacher efficacy as they began their careers" (Ronfeldt et al., 2013, p. 331). While Delgado (2019) discovered a relationship between autonomy and mentoring, the study found that identity development was more important in cultivating autonomy in preservice teachers. However, Mokoena & van Tonder (2024) noted that mentoring had a powerful effect on the development of self-directedness in early career teachers, emphasizing the importance of mentorship for both preservice and novice teachers in the development of autonomy over time.

When considering instructional resources including textbooks and online documents, the SPTM note, "When the materials fall short of the standards or expectations, well-prepared beginners are able to decide whether to replace or adapt the materials to better address the content and process expectations" (AMTE, 2017, p. 10). The Council for the Accreditation of Educator Preparation (CAEP) standards also support instructional autonomy stating:

> Candidates may modify the lesson objective, resources and materials, activity structure, time allocations, learning environment or instructional approach. Candidates may invent an example or an analogy, insert a mini-lesson, suggest a different perspective, omit a planned activity, alter a planned order of instruction, help students make connections, anticipate an upcoming difficulty, or enrich and accelerate instruction. Candidates flexibly use resources beyond those provided in the curriculum. (Council for the Accreditation of Educator Preparation, 2018, p. 23)

However, in some cases PSTs do not have the autonomy described in the SPTM and CAEP standards as cooperating teachers expect them to replicate the same teaching approach that they themselves use, limiting the preservice teachers' freedom to experiment with different teaching approaches and identities (Frykholm, 1996; Weasmer & Woods, 2003). Classroom teachers serving as cooperating teachers may also face limitations in their instructional autonomy due to policies, curriculum requirements, or pacing pressures (Narayanan et al., 2024), limitations that may be extended to their student teachers. Many preservice teachers rarely see themselves as holding power that is necessary for change or reform within the schools and feel they need to "play by the rules," "not rock the boat," and "respect the norms" of their cooperating teachers while in their field placements (Delgado, 2019; Frykholm, 1996; Whitney et al., 2002; Wilson et al., 2002). These expectations can make it difficult for preservice teachers to try out new teaching approaches.

Even when elementary student teachers indicate a desire to teach mathematics in ways that align to a standards-based approach, their relationship with their cooperating teacher influences how they implement their instruction (Kang, 2016). Often, preservice teachers will fall back on traditional teaching approaches that align with their own experiences when faced with external challenges or lack of support (Smith, 1996). In cases when student teachers do attempt to use EPP-supported teaching methods, they may feel alone since their cooperating teacher may not use the same methods. In addition, simply being given the opportunity to try a new approach may not be enough since the student teacher needs to feel successful in their implementation through modeling, guidance and feedback (Ronfeldt & Grossman, 2008), components emphasized in Bandura's social cognitive theory.

While literature on student teachers perceived instructional autonomy is limited, one study found that student teachers who reported more instructional autonomy also reported a desire to stay in the teaching profession for significantly more years (Ronfeldt et al., 2013). An additional study of preservice special education teachers found that the participants' desire for autonomy was limited earlier in their program but increased over three years (Gidalevich & Shalev, 2022). Additional studies on student teacher autonomy would be useful for exploring another dynamic of the student teacher-cooperating teacher dynamic and the effects on instructional practices.

Challenges of Inquiry-Based Teaching

The relationship between preservice teachers' prior math experiences, the inquiry-based ideas promoted in their EPP coursework, and the conflicting information often experienced in field placements can make it difficult for PSTs to feel confident with implementing inquiry-based teaching approaches. Even if educator preparation programs change student teachers' beliefs toward an inquiry-based approach to teaching mathematics, Jansen et al. (2017) found "...that developing beliefs is not enough to support learning to teach for conceptual understanding" (p. 248). They may find value in the inquiry-based practices, but they must also develop the skills needed to teach using an inquiry-based approach and feel they have the autonomy to do so.

Developing the skills needed to teach using an inquiry-based approach can be difficult, requiring time and skill from teachers (Seely, 2014). Smith (1996) reflects on the multiple ways that teachers respond to reform movements that call for innovative teaching approaches stating:

> Mathematics teachers, both practicing and prospective, respond to the reforms in different ways: from ignoring, downplaying, or openly resisting the changes; to retaining the telling model under the cover of reform; to embracing the heart of the reform, struggling to change, but falling short; to managing deep changes, and achieving new levels of success (p. 395).

Nearly 30 years later, PSTs continue to share concerns about implementing inquiry-based instructional practices. Key concerns include time needed to teach in this new way, limitations of their own content knowledge, students' abilities to engage in problem solving, hesitation about how students would respond to methods that were different from traditional instruction, inconsistencies across grade levels, and cooperating teachers who did not use reform ideas in their own practice (Johnson et al., 2019). Additional challenges include reliance on established teaching methods, reluctance to try new strategies, and their perception of their own creativity and confidence (Li et al., 2024). Multiple studies point to the cooperating teacher, the curriculum, departmental policies, or lack of student ability as factors that keep preservice teachers from experimenting with teaching approaches that may align more to reform efforts (Frykholm, 1996; Gholam, 2019; Rondefeldt & Grossman, 2008). Combined with the conflicting experiences in K-12 classrooms, EPP programs, and field experiences, it is not surprising that

PSTs find it difficult to implement inquiry-based instruction, despite ambitious visions and recommendations from organizations like AMTE and NCTM.

Conclusion

Rondfeldt & Grossman (2008) studied professional identity by examining preparation of clergy, teachers, and clinical psychologists. They found the tensions between preparation programs and how students were developing their professional selves were strongest in teacher education due to new teachers attempting to serve as change agents in their field. The pressure felt by preservice teachers to serve as “change agents” is apparent as EPPs rely on developing teachers to break the cycle of traditional math teaching approaches in favor of inquiry-based methods.

However, transitioning preservice teachers into the field is becoming more difficult using traditional mentor models since the mentor may be using pedagogical approaches that do not align with reform mathematics initiatives (Wang & Odell, 2007). As student teachers begin taking more ownership during their student teaching semester, it is worth examining which factors ultimately hold the most influence over the pedagogical decisions that they make when planning and implementing mathematics instruction. The current study will build on this literature review by examining four variables that are crucial to effective mathematics teaching: ST’s math teaching efficacy (composed of personal teaching efficacy and outcome expectancy), STs perceived instructional autonomy, and STs’ reporting of their cooperating teachers’ implementation of IBMI. The study will fill a gap in the literature by specifically measuring ST’s math teaching efficacy related to inquiry-based practices. Additionally, the study will contribute to the literature by examining ST’s perceived instructional autonomy, a topic that is limited in current research publications. The results of the study can help determine which factors lead to inquiry-based teaching so that EPPs can leverage coursework and field experiences in productive ways.

Chapter 3 - Methodology

Introduction

This study aims to explore whether a relationship exists among four independent variables and the extent to which elementary student teachers (EST) self-report implementation of inquiry-based mathematics instruction (IBMI). The four independent variables include: EST's inquiry-based math teaching efficacy (composed of personal teaching efficacy and outcome expectancy), EST's perceived instructional autonomy, and EST's reporting of their cooperating teachers' (CT) implementation of IBMI. Bandura's (1989) social cognitive theory (SCT) served as a framework for choosing the independent variables. SCT emphasizes the relationship between personal factors, environmental factors, and behavior. Inquiry-based math teaching efficacy serves as a personal factor in the study, while student teachers' reporting of their cooperating teachers' implementation of IBMI and their perceived instructional autonomy serve as environmental factors that can contribute to inquiry-based teaching behaviors. Results from the study can help teacher educators understand the extent to which these factors may influence whether student teachers use an inquiry-based approach when teaching mathematics as they transition into their early careers. Additionally, results could inform teacher educators' decision making about changes to mathematics education programs to increase the likelihood that early career teachers will use research-based instructional practices.

Research Questions and Hypotheses

This study addresses the research questions below:

RQ1: To what extent is elementary student teachers' self-reported implementation of inquiry-based mathematics instruction associated with their perceptions of math teaching efficacy, instructional autonomy, and cooperating teachers' implementation of inquiry-based instruction?

RQ1 will be the focus of the study to identify which variables show the strongest relationship to elementary student teachers' self-reported implementation of inquiry-based math instruction. While previous literature has identified these variables as important components to developing effective elementary mathematics teachers, this study will examine how the variables account for the variance in student teacher' implementation of inquiry-based math instruction. The study specifically explores the idea outlined in the social cognitive framework that different sources of influence can vary in strength (Bandura, 2014).

RQ2: To what extent does the relationship between elementary student teachers' implementation of inquiry-based mathematics instruction and math teaching efficacy differ by their perceptions of instructional autonomy and cooperating teachers' implementation of inquiry-based instruction?

RQ2 will be considered exploratory. Social cognitive theory explains that environmental, personal, and behavioral factors interact reciprocally to influence behavior. With this in mind, this research question aims to explore whether the relationship between efficacy and implementation of inquiry-based instruction differs based on factors related to the cooperating teacher, especially given that previous literature identifies the cooperating teacher as the most influential factor on student teachers (Anderson, 2009; Frykholm, 1996; Peterson & Williams, 2008; Whitney et al., 2002; Yee, 1969; Zeichner, 1980). The moderation regression analysis attempts to measure the interaction effect between an environmental factor (cooperating teacher variable) and a personal factor (efficacy) on behavior (implementation of IBMI).

The null and alternate hypotheses are summarized below in table 3.1 with ESTs' self-reported implementation of inquiry-based math instruction (STIBMI), ESTs reporting of their CT's implementation of inquiry-based math instruction (CTIBMI), personal inquiry-based math teaching efficacy (PIBTE), inquiry-based math teaching outcome expectancy (IBMTOE), and student teachers perceived instructional autonomy (STPIA).

Table 3.1

Null and Alternate Hypothesis for each research question

RQ1	
Null Hypotheses	**Alternate Hypotheses**
H_{10}: PIBMTE is not related to STIBMI.	H_{1a}: PIBMTE is related to STIBMI.
$H_{20:}$ IBMTOE is not related to STIBMI.	H_{2a}: IBMTOE is related to STIBMI.
H_{30}: CTIBMI is not related to STIBMI.	H_{3a}: CTIBMI is related to STIBMI.
H_{40}: STPIA is not related to STIBMI.	H_{4a}: STPIA is related to STIBMI.
RQ2	
Null Hypotheses	**Alternate Hypotheses**
H_{50}: The relationship between PIBMTE and STIBMI does not differ by CTIBMI.	H_{5a}: The relationship between PIBMTE and STIBMI differs by CTIBMI.
H_{60}: The relationship between PIBMTE and STIBMI does not differ by STPIA.	H_{6a}: The relationship between PIBMTE and STIBMI differs by STPIA.
H_{70}: The relationship between IBMTOE and STIBMI does not differ by CTIBMI.	Ha: The relationship between IBMTOE and STIBMI differs by CTIBMI.
H_{80}: The relationship between IBMTOE and STIBMI does not differ by STPIA.	H_{8a}: The relationship between IBMTOE and STIBMI differs by STPIA.

Study Context, Population, and Sample

Study Context, Population, and Sample

Ravid (2020) suggests that researchers using convenience sampling should begin the study by identifying the population of interest and intentionally selecting a sample from that population. The researcher followed this process by first identifying the population for the study to include student teachers in accredited elementary or early childhood education preparation programs in Missouri and Kansas. After experiencing low survey completion early in data collection, the study was expanded to also include accredited EPPs in Illinois, Iowa, and Nebraska to capture more of the midwestern region. The researcher found a list of accredited EPPs on each state department of education website and emailed the listed contact requesting that the survey be distributed to elementary student teachers at the institution. A follow-up email was sent to the university contacts 7-10 days following the first request.

To qualify for the study, participants had to complete a minimum of twelve weeks of student teaching in a certified teacher's K-5 classroom, and mathematics had to be included as part of their teaching responsibility. All preservice teachers who received the survey were given an opportunity to participate in the study. Because the researcher was unable to send the survey directly to the participants and instead had to rely on representatives from each university to share the survey with their students, the total number of student teachers who received the survey is unknown. However, Qualtrics recorded a total of 238 respondents who started the survey. Of those, 14.7% were removed (n = 35) because they did not meet one or more of the qualifications listed previously. Of those who started the survey, 30% (n = 73) did not complete the entire survey and the responses were not included in any data analysis.

Table 3.9 summarizes the sample after incomplete responses were discarded. Note that while EPPs in Iowa were contacted, none of the responses noted institutions in Iowa when completing the survey. Three respondents chose not to include their EPP in their response.

Table 3.2

Summary of Sample Population by State

	Illinois	Kansas	Missouri	Nebraska	Totals
Total accredited EPPs in state	54	24	42	16	136
EPPs represented in final data	4	4	13	1	22

Sample size	$n = 16$	$n = 33$	$n = 75$	$n = 3$	$N = 130$

Research Design and Data Collection Schedule

Creswell (2014) describes quantitative research as "an approach for testing objective theories by examining the relationship among variables" (p. 32). The goal of the study is to examine possible relationships between four independent variables and elementary student teachers' self-reported use of inquiry-based mathematics instruction. The independent variables in the study include student teachers' inquiry-based teaching efficacy (composed of personal teaching efficacy and outcome expectancy), perceived instructional autonomy, and the student teachers' reporting of their cooperating teachers' use of IBMI. The dependent variable is the extent that student teachers report using inquiry-based teaching practices in mathematics during their student teaching semester. Quantitative methods are necessary since the study examines a relationship among variables and assigning value to the variables allows us to determine the strength and direction of the relationships found.

The study used a cross-sectional survey design to collect data from elementary student teachers using a researcher-developed questionnaire consisting of five subscales to measure each of the variables. The Institutional Review Board (IRB) approval was obtained in December 2024 and a pilot study was completed. Upon approval from the dissertation committee, an amendment to the IRB was submitted for the revisions to the questionnaire and data collection began in April 2025. This timeline was chosen to align with the end of the spring semester so that participants were able to reflect on their full student teaching experience as they completed the questionnaire.

First, the researcher established individual contacts at each university. These contacts often took on the role of education faculty or directors of certification at the universities included in the study. The contacts were asked to share the questionnaire, administered through Qualtrics, with elementary student teachers in their programs. Some agreed to email the questionnaire to the participants, while others shared the information in face-to-face courses or posted the link on learning management systems for participants to access online. Because distribution of the instrument depended on university contacts, a follow-up email was sent approximately 7-10 days after the initial request to remind them to share the link or to request that they resend it to elementary student teachers. As an instructor at a university, the researcher shared the questionnaire with elementary student teachers at her university through email. The student teachers were not under her supervision nor were they enrolled in any of the researcher's courses at the time. Responses to the questionnaire were anonymous (Bandura, 2006; Fink, 2006).

Threats to Validity

Threats to Internal Validity

Because the student teachers are self-reporting, there is a possibility of social desirability bias. Respondents may answer based on what they believe is the "correct" response, particularly in alignment with what they have been taught in their program, rather than reporting their actual behaviors. This risk may be greater for participants who previously had the researcher as an instructor. Recall bias is also a potential threat, as participants were asked to reflect on their teaching behaviors, perceived autonomy, and their cooperating teacher's practices over many weeks of the student teaching semester. Other factors not included in the study, such as the student teacher's math content knowledge, cooperating teacher's years of teaching experience, school culture, and curriculum policies may also influence the variables examined. Finally, because data were collected at a single point in time, the study cannot establish causation among variables.

Threats to External Validity

The study population consisted of student teachers from midwestern educator preparation programs, which may limit generalizability to other regions of the United States. State-level policies, testing mandates, and standards vary across contexts and were not accounted for in the study design. While all participating programs required at least twelve weeks of student teaching, the number of field hours and structure of clinical experiences differed among programs. Because data were collected during student teaching, findings may not generalize to participants' first years as certified teachers when variables such as autonomy may change significantly.

The sample consisted primarily of females between the ages of 18 and 23, limiting representation from other genders and age groups. Additionally, 43% of participants reported on instructional practices and perceived autonomy in suburban schools, so differences may exist for participants in rural or urban settings.

Threats to Construct Validity

Following pilot testing, the number of items measuring each variable was reduced to improve completion rates. After factor analysis, the STIBMI and CTIBMI subscales were further reduced to four items each based on factor loadings. These reductions may have limited the ability to fully capture the complexity of the constructs. Because student teachers reported on both their own instructional practices and those of their cooperating teachers, their responses may not accurately reflect actual classroom behaviors. Observations might yield different data than self-reports, particularly if participants lacked sufficient experience identifying inquiry-based instructional practices. Finally, variation in how participants interpreted survey items may have introduced measurement error. Because construct validity takes time to establish and the subscales are newly developed, additional experimentation would be needed to confirm construct validity (Fink, 2006).

Instrumentation

A questionnaire is "a survey instrument containing the questions in a self-administered survey" (Check & Schutt, 2012) and is effective for gathering information about attitudes and beliefs, perceptions, and behaviors (Artino et al., 2014; Creswell, 2014). The variables examined in this study include both personal and environmental factors that would fall under these categories. Because the variables being studied are rather complex, subscales were created for each variable to "capture the different facets" of the construct (Artino et al., 2014, p. 464). Self-administered questionnaires are effective when response categories are complex and questions tend to be closed, both of which are true of this study (Fowler, 2009).

Prior to creating each subscale, the researcher examined existing instruments to determine if a new one was needed and to improve upon limitations of previously published instruments (Clark & Watson, 1995; Pett et al., 2003). Prior instruments on mathematics instruction and efficacy did not emphasize an inquiry-based approach, and autonomy instruments focused on in-service rather than preservice teachers. Therefore, new subscales were developed to eventually be combined into one questionnaire for the study. The researcher considered multiple designs for each subscale regarding response categories and scale ranges (i.e. 0-100, 1-5). Previous studies offered differing results, and the literature is inconsistent with recommendations in these areas. For example, one study found that 11-point Likert scales lead to more variance than 5-point Likert scales, arguing that the 11-point scale is more helpful when conducting statistical analysis (Chyung et al., 2018). Bandura (2006) suggested that scales with fewer steps should be avoided, and a 0-100 scale is recommended. Dillman et al. (2014) provides a different perspective stating that when the scale range is too large the responses tend to "cluster" around the ends. He states, "...one must provide a scale that is long enough to represent the entire continuum of possible answers, but without so many categories that they begin to burden respondents or that the difference between any two categories becomes so small as to be practically meaningless" (p 153). All the previous literature was considered when developing each of the five subscales and decisions were made based on which variable was being measured.

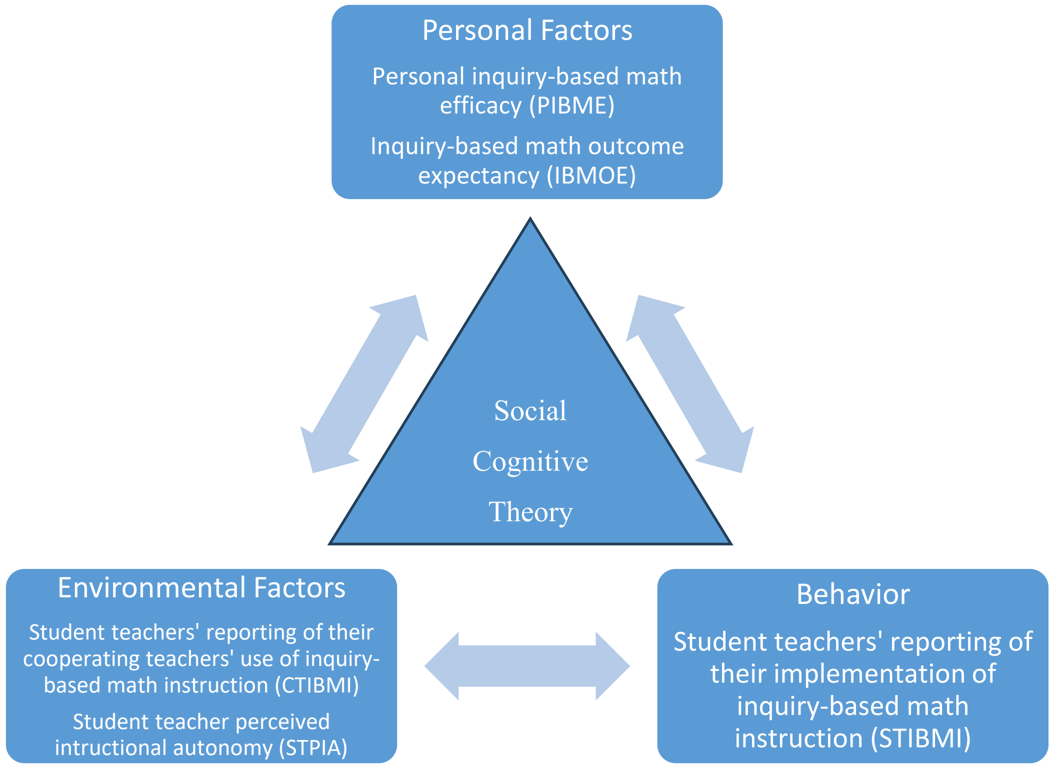
The researcher also considered whether bipolar (i.e. strongly disagree to strongly agree) or unipolar scales (i.e. not confident to completely confident) would be most appropriate for measuring each variable. DeCastellarnau (2018) describes the difference between the two by stating "while bipolar scales ask about the neutrality, the direction and intensity of an opinion, unipolar scales only ask about the extremity or intensity" (p 1529). Bandura (2006) specifically notes that self-efficacy should be measured using a unipolar scale stating that "they do not include negative numbers because a judgment of complete incapability (0) has no lower gradations" (p 312). When designing the subscales, the researcher chose a unipolar scale as most appropriate for each variable, using Dillman et al. (2014) recommendation of 4 points since decreasing the number of scales also decreases cognitive burden and participants will likely have an opinion for most of the items, eliminating the need for a "no opinion" option. Each point was labeled with words rather than numbers and the researcher chose to avoid sliding scales since studies showed sliding scales took longer and led to more incomplete responses (Dillman et al., 2014). Additionally, the items in each subscale scale were randomized to reduce response pattern bias.

Identifying variables for the study

Prior to creating a questionnaire, it is suggested that the researcher begin with a thorough review of the existing literature (Artino et al., 2014; Clark & Watson, 1995; Pett et al., 2003). Therefore, existing literature was examined specifically through the lens of Bandura's (1989) Social Cognitive Theory. SCT states that behavior is influenced by both personal and environmental factors and this framework was central in determining which factors to focus on for this study. Initially, two personal factors (student teacher attitude and student teacher teaching efficacy) were selected as independent variables for the study. After analyzing pilot data, the attitude items were revised and renamed as outcome expectancies as part of the efficacy framework. Additionally, two environmental variables (ESTs' reporting of their CTs' implementation of IBMI and ESTs perceived instructional autonomy) were also selected as part of the study based on an abundance of literature stating that the cooperating teacher is the most influential on student teachers (Anderson, 2009; Frykholm, 1996; Peterson & Williams, 2008; Whitney et al., 2002; Yee, 1969; Zeichner, 1980). Figure 3.1 illustrates the relationship between the Social Cognitive Theory Framework and the variables in the study.

Figure 3.1

Social Cognitive Theory and Present Study



The steps recommended by Artino et al. (2014) were followed from January 2024-March 2025 as initial subscales for each of the five variables were developed by the researcher. Three mathematics education professors were identified as content experts (Check & Schutt, 2012) and examined the items based on "representativeness, clarity, relevance, and distribution" to establish content validity (Artino et al., 2014, p. 467) and several cycles of revisions were conducted. Fellow mathematics education doctoral students reviewed the items in the student teacher inquiry-based mathematics instruction subscale to ensure that "the questions mean the same thing to every respondent" (Fowler, 2009). Clarity and comprehensiveness are important aspects of item development (Rae & Parker, 2014; Check & Schutt, 2012), and both aspects were reviewed multiple times using prompts in ChatGPT, an AI-based language tool, to ensure clarity, conciseness and validity.

Pilot testing

When developing a new instrument, it is suggested that the instrument be used in pilot testing (Artino et al., 2014; Check & Schutt, 2012; Rea & Parker, 2014). During November and December 2024, the questionnaire was sent to student teachers at two mid-western universities to resemble the study's general population (Check & Schutt, 2012; Rea & Parker, 2014). The questionnaire included 1 item providing consent to participate in the study, 2 qualifying items, 50 items measuring the five variables in the study, and 13 demographic items for a total of 66 items. Rea & Parker (2014) suggested a pretest aim for 20 - 40 respondents. In the pilot study, 30 respondents started the survey, two were not included due to not meeting the parameters for the population, and 14 were not included because they did not complete all five subscales leading to a 46.6% completion rate. The average time to complete the questionnaire was about 11 minutes, meeting the recommendation of less than 15 minutes (Rea & Parker, 2014).

Rea & Parker (2014) note that with a sample size this small, the pretest is not aiming to show statistical accuracy but rather assess the quality of the questionnaire. Furthermore, it is recommended that the ratio of respondents to variables should be 10:1 (Yong & Pearce, 2013), requiring 50 respondents for factor analysis to yield accurate results for the pilot. Therefore, factor analysis was not conducted on the pilot data. Based on the 46.7% completion rate, the researcher aimed to shorten the questionnaire given that nearly half of those who started the survey quit before finishing. Careful consideration was given to the shortening of each subscale since Cronbach's alpha is typically higher when there are more items comprising a scale (Artino et al., 2014; Streiner, 2003). However, it is also noted that questionnaires with more items tend to have lower response rates and can also cause respondents to become fatigued, leading to concomitant response errors (Artino et al., 2014; Rea & Parker, 2014). The instrument was eventually revised, decreasing the number of independent variables from four to three and decreasing the total number of items from 66 to 50.

A progress bar was also added to help respondents visually see their completion, and the researcher chose to include a random drawing for four $25 Amazon gift cards to increase participation and completion. The order in which the subscales were presented was revised to decrease cognitive load and make the questionnaire flow more naturally (Check & Schutt, 2012). The next several sections outline how each subscale was developed as well as revisions that were made after viewing the pilot data and exploratory factor analysis. Below is a summary of the questionnaire that was administered to study participants for final data collection.

Table 3.3

Overview of Administered Questionnaire

Subscales	Item Totals	Reverse-Coding	Dimensions	Sample Items
Student Teacher Inquiry-Based Mathematics Instruction (STIBMI)	9	3	Lesson structure, student role, teacher role	How often did you use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas? How often did you begin lessons by demonstrating a procedure before having students solve similar problems using the same procedure?
Cooperating Teacher Inquiry-Based Mathematics Instruction (CTIBMI)	9	3	Lesson structure, student role, teacher role	How often did your cooperating teacher use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas? How often did your cooperating teacher begin lessons by demonstrating a procedure before having students solve similar problems using the same procedure?

Inquiry-Based Mathematics Teaching Efficacy (IBMTE)	13	0	Personal teaching efficacy, outcome expectancy	I can effectively adapt my questioning based on the strategies students use to deepen their understanding of the problem. My use of inquiry-based instruction can increase motivation in students who are usually unengaged.
Student Teachers' Perceived Instructional Autonomy (STPIA)	8	4	Planning and teaching	My cooperating teacher supported my decisions about how to adjust instruction during mathematics lessons. I felt pressured to teach in a way that aligned with my cooperating teacher's preferences.
Demographics	10	0	Personal, education, field-related	During your student teaching semester, approximately how many math lessons did you teach? While teaching mathematics, what was the average class size?

Reliability and Validity Procedures for Each Scale

After data collection, incomplete responses were removed from the dataset. Reverse-coded items were recoded, when necessary, to align with the direction of the other items. For example, a response of 4 for the item "I felt pressured to teach in a way that aligned with my cooperating teacher's preferences" was recoded as a 1 to indicate a low level of perceived instructional autonomy. The compute procedure was conducted to create a total score for each variable (Yockey, 2023).

Prior to any analysis, Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy (greater than 0.5) and Bartlett's test of sphericity (less than 0.001) were evaluated to confirm that the data met the requirements for factor analysis. The anti-image matrices were used to confirm that the KMO for each item was greater than 0.5 and items under this threshold were removed and the KMO test was run again to account for any change (Field, 2018). To evaluate construct validity, exploratory factor analysis (EFA) was used to assess the underlying factor structure of each scale (Field, 2018) with the goal of determining whether each set of items measured a single construct. Principal axis factoring, which assumes that the sample is the population, was used which means that the results can only be applied to the sample collected (Field, 2018). Additionally, direct oblimin rotation was used as advised by Field (2018) since it was likely that there was some correlation among the factors. Items with substantial cross-loadings and items with factor loadings below 0.4 were removed (Field, 2018).

The theory of reliability states that an observed score is composed of a true score and an error score, illustrated by $X = T+E$ (Ravid, 2020). Errors always occur but can be addressed through careful design (Creswell, 2014). Revisions were made to the items on the subscales according to EFA, and Cronbach's alpha was calculated to measure internal consistency reliability (Ravid, 2020) with coefficient alpha of at least 0.7 being considered acceptable (Lamm et al., 2020). In addition to factor loadings, item-total statistics were used to determine which items should be removed. Corrected item-total correlations less than 0.3 and items that negatively affected the internal consistency (Cronbach's alpha if item deleted) were considered for removal to strengthen the reliability of the subscale (Field, 2018). The number of factors retained were determined based on eigenvalues greater than 1.0, scree plots, and an adequate degree of internal consistency of the subscale (Field, 2018). The following sections outline the process followed by the researcher to develop and refine each subscale starting with existing literature and frameworks for each variable in combination with the results of EFA and Cronbach's alpha. Charts illustrating the initial subscales and refined subscales can be found in appendix A.

Developing the Student Teacher Inquiry-Based Mathematics Instruction (STIBMI) Subscale

In the initial pilot study, this subscale was called "problem-based math teaching." Problem-based learning (PBL) is defined as:

> PBL immerses students in real-world problems, encouraging them to apply mathematical concepts in context. Rather than learning theoretical concepts in isolation, students work through practical challenges-such as designing a bridge, analyzing data, or optimizing a business process-using mathematics as a tool (Vijayaprabha et al., 2015).

While real world problems are certainly an important component of effective math teaching, the items included other constructs such as the structure of the lesson, multiple representations, questioning, and assessment. For that reason, the subscale was renamed Inquiry-Based Mathematics Instruction (IBMI) to include other components of math instruction outside of the use of real-world problems. IBMI uses several frameworks including Standards of Mathematical Practice (CCSSM, 2010), Cognitively Guided Instruction (Carpenter & Fennema, 1992), and the Mathematics Teaching Practices (NCTM, 2014). For this research, IBMI is described as follows:

> The teacher begins the lesson by providing students with a real-world task or open-ended problem to explore before providing direct instruction or modeling a solution. The teacher encourages students to solve the problem using a variety of strategies, facilitates discussions where students share and defend their thinking, and supports students through productive struggle with intentional questioning.

The teacher concludes the lesson by purposefully highlighting big mathematical ideas and may model an example if necessary.

A review of the literature did not show an existing instrument that fully measured inquiry-based mathematics instruction. Carney et al. (2015) developed the *Frequency of Mathematics Instructional Practices Survey* that measured the frequency with which teachers engage in social-constructivist and transmission oriented instructional practices. While their instrument included several elements of inquiry-based instruction, some components such as assessment, the use of real-world problems, and the emphasis on student exploration prior to teacher modeling were not included, showing the need for a new instrument.

Because conducting classroom observations can be time consuming and the study aimed to target a larger sample, elementary student teachers used self-reporting to describe their mathematics instruction. Ross et al. (2003) note concerns about accuracy in teacher self-reports stating, “Teachers may not have the same understanding of the items in the survey as its developers intended” (p. 345). This suggestion is supported by a study where preservice mathematics teachers reported that they implemented standards-based teaching, but observations showed more traditional approaches (Frykholm, 1996). This finding is concerning given the current study where student teachers are asked to report on their use of inquiry-based methods when teaching mathematics. To address this concern, Burstein et al. (1995) suggest that “the solution is to make problematic survey items clearer through the use of more precise definitions and concrete examples” (p. 56). Rather than asking student teachers how often they teach using an inquiry-based instructional approach, which could be misinterpreted or generalized, the researcher created items that specifically describe a behavior that would take place during inquiry-based lessons contrasted with behaviors exhibited in more traditional teaching scenarios.

The description of IBMI outlined above was also provided in the questionnaire. The NCTM Math Teaching Practices (NCTM, 2014) and Standards of Mathematical Practice (CCSSM, 2010) were frameworks that guided the development of these items. For example, inquiry-based behaviors focus on starting lessons with real-world problems, allowing multiple strategies and approaches, including the use of manipulatives in solving problems, facilitating discussions around different strategies, embracing multiple measures of assessment, and using questioning to support productive struggle.

Initially the researcher, with the feedback and support of mathematics education professors, created a subscale consisting of ten items, with five of them needing to be reverse-coded. Respondents rated how often they exhibited each behavior during their student teaching experiences while teaching mathematics using a 4-point Likert scale ranging from *no lessons, a few lessons, most lessons, all lessons*. These scale labels were selected to generalize the frequency that student teachers performed each behavior given that there would be inconsistency in the number of mathematics lessons taught during each student teaching experience. Higher scores on the subscale indicated a higher degree of self-reported inquiry-based math instruction.

After collecting pilot data, the items on the STIBMI subscale were revised. First, the researcher noticed that some items were not mutually exclusive to inquiry-based instruction and could be observed in a traditional mathematics classroom, decreasing the face validity of the instrument. Below is one example of a revision to increase face validity:

> Original item: How often did you incorporate the use of manipulatives (concrete or virtual) to help students learn mathematics?
>
> Revised item: How often did students use concrete or virtual manipulatives to explore problems before you provided direct instruction?

When considering the original item, it is possible that a teacher might often use manipulatives to model a way to solve a problem before asking students to mimic the same approach, which describes a more traditional teaching style. Since a higher score on this item indicates more frequent use of inquiry-based instruction, the results could be misleading. The revised item emphasizes the role of the manipulatives as a way for students to explore a problem and clarifies that the exploration should occur before direct instruction, both important aspects of inquiry-based instruction.

Additionally, several items were removed that closely measured the same construct and additional items were created to address missing components of inquiry-based instruction. For example, the two items below were added to measure assessment with the goal of increasing content validity.

- How often did you ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?
- How often did you assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?

The new subscale contained nine items, which measured the extent to which student teachers used inquiry-based instruction, with three of those items requiring reverse coding. With a total of (N = 130) complete responses, Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity were used to determine if the data was suitable for exploratory factor analysis (EFA). The KMO value was 0.67, indicating mediocre sampling adequacy (Kaiser, 1974), and Bartlett's test of sphericity was significant, ($\chi^2(36) = 140.32$, $p < 0.001$), suggesting that the data were suitable for factor analysis. Because the subscale was newly constructed and not previously validated, EFA was conducted to assess construct validity. The scree plot (see appendix B1) showed a 2-factor solution while eigenvalues greater than 1.0 (see appendix B2) showed a 3-factor solution. When examining the pattern matrix (see appendix B3), STIBMI-1 did not load above 0.3 on any of the factors and was removed from further analysis. The second factor showed the recoded items (STIBMI 2, 5, and 7) as loading together all of which described traditional mathematics teaching methods. This factor was not included since the subscale was meant to measure inquiry-based math instruction. The items on the third factor (STIBMI 5 and 6) loaded negatively and STIBMI-5 cross-loaded onto factor 2. For these reasons, the third factor was also eliminated.

The first factor seemed to describe the essential elements of inquiry-based instruction according to the Math Teaching Practices and Standards of Mathematical Practice, and included four items (STIBMI 3, 4, 8, 9) with loadings above the 0.4 threshold. Ultimately only factor one was retained, accounting for 18.36% of the total variance in the item responses. The final subscale consisted of four items measuring student teacher's inquiry-based behaviors during mathematics instruction.

The Cronbach's alpha of the 4-item STIBMI subscale was 0.65, indicating a marginal degree of internal consistency among the items (Yockey, 2023). The item-total statistics (see appendix B4) did not show that removing items would increase reliability. The means of the individual items (see appendix B5) ranged from 2.28 to 3.0, with a mean on the total subscale of 11.00(SD=2.20). While 0.65 is below the often recommended 0.7 threshold, research confirms that scales with fewer items often show lower coefficient alphas (Artino et al., 2014; Streiner, 2003). Additionally, a Cronbach alpha of 0.5 - 0.6 is generally acceptable during early stages of research and item-total correlation should also be examined when determining reliability (Streiner, 2003). The mean item-total correlation for the STIBMI subscale was 0.31, meeting the recommended range (Streiner, 2003). The STIBMI subscale was used as the dependent variable and potential revisions are discussed in chapter 5.

Table 3.4

Summary of final STIBMI Subscale

Items	Factor Loading	MTP Connections	SMP Connections
How often did you use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	0.71	2, 3, 4	4, 5
How often did students use concrete or virtual manipulatives to explore problems before you provided direct instruction?	0.59	2, 6	1, 5
How often did you assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	0.48	7	1, 3, 4
How often did you ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	0.47	5	3
Cronbach's alpha	0.65		
Inter-item correlation mean	0.31		

Note. Only loadings ≥ 0.30 are shown

Developing the Cooperating Teaching Inquiry-Based Mathematics Instruction (CTIBMI) Subscale

To examine the relationship between observed and implemented inquiry-based mathematics instruction, the same nine items were used to measure how much inquiry-based teaching student teachers observed in their cooperating teacher's instruction. Rather than asking about themselves, the items asked how often their cooperating teacher performed each of the nine behaviors. With a total of ($N = 130$) complete responses, Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity were used to determine if the data was suitable for exploratory factor analysis (EFA). The KMO value was 0.78, indicating middling sampling adequacy (Kaiser, 1974), and Bartlett's test of sphericity was significant, ($\chi^2(36) = 314.79$, $p < 0.001$), suggesting that the data were suitable. EFA was conducted to assess construct validity since this was not previously validated. The scree plot and eigenvalues greater than 1 (see appendices C1 and C2) showed a 2-factor solution. When examining the pattern matrix (see appendix C3), the second factor showed the recoded items as loading together all of which described traditional mathematics teaching methods. This factor was not included since the scale was meant to measure inquiry-based math instruction. The first factor seemed to focus on practices consistent with inquiry-based mathematics instruction and included six items (CTIBMI 1, 3, 4, 6, 8, 9) with loadings above 0.4. This factor accounted for 30.80% of the total variance in the item responses.

Six items of the CTIBMI loaded onto the first factor. These included four items (CTIBMI 3, 4, 8, 9) that were the same as those retained for the STIBMI. As this study focuses on the relationship between the student teachers' self-reported use of inquiry-based math instruction and the extent to which they observe the same practices being used by their cooperating teacher, the four items that were consistent between the STIBMI and the CTIBMI were retained. CTIBMI-1 had a loading of 0.48 which is relatively low, and although CTIBMI-6 had a higher loading of 0.77 its content was already reflected in the retained four questions.

The Cronbach's alpha of the 4-item CTIBMI subscale was 0.74, indicating a fair degree of internal consistency among the items (Yockey, 2023). The item-total statistics (see appendix C4) did not show that removing items would increase reliability. The means of the individual items (see appendix C5) ranged from 2.24 to 2.84, with a mean on the total subscale of 10.43($SD = 2.60$). The item-total correlation mean was 0.42.

Table 3.5

Summary of final CTIBMI Subscale

Items	Factor Loadings	MTP Connections	SMP Connections
How often did your cooperating teacher ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	0.78	5	3
How often did your cooperating teacher use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	0.65	2, 3, 4	4, 5
How often did your cooperating teacher assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	0.63	7	1, 3, 4
How often did students use concrete or virtual manipulatives to explore problems before your cooperating teacher provided direct instruction?	0.50	2, 6	1, 5
Cronbach's alpha	0.74		
Item-total correlation mean	0.42		

Note. Only loadings ≥ 0.30 are shown

Developing the Student Teacher Perceived Instructional Autonomy (STPIA) Subscale

Lack of literature around student teachers perceived autonomy provided by their cooperating teacher also led to the development of a new subscale. Friedman (1999) created the Teacher-Perceived Work Autonomy Scale (TWA) which outlined four subscales of teacher autonomy including student teaching and assessment, school mode of operating, staff development, and curriculum development. Later, Ulas & Aksu (2015) developed the Teacher Autonomy Scale for Turkish Teachers which identified three areas of autonomy: autonomy in instructional planning and implementation, autonomy in professional development, and autonomy in determining the framework of the curriculum. Both scales were developed with and intended for in-service elementary teachers rather than the preservice population used in the current study. Ronfeldt et al. (2013) created a subscale measuring student teachers' instructional autonomy, however, the items focused on general autonomy rather than measuring the autonomy provided by the cooperating teacher. Student teachers were asked to indicate how much control they had over a variety of instructional practices including selecting content, teaching techniques, disciplining students, grading, and homework.

In considering the three levels of autonomy provided by Ulas & Aksu (2015), only the first area of autonomy in instructional planning and implementation seemed relevant to student teachers and their relationship with their cooperating teacher and this area became the framework of the Student Teacher Perceived Instructional Autonomy (STPIA) subscale. The newly created subscale initially consisted of ten items, five of which needed to be reverse-coded. The items focused on the extent to which student teachers felt supported by their cooperating teacher in planning and implementing mathematics instruction based on their own views and beliefs. Respondents used a 4-point Likert scale choosing from *not true at all, sometimes true, mostly true, or completely true* to measure their perceived autonomy, with higher scores indicating more perceived autonomy. Revisions after the pilot study resulted in eliminating two redundant items, with a total of eight remaining items.

With a total of ($N = 130$) complete responses, Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity were used to determine if the data was suitable for exploratory factor analysis (EFA). The KMO value was 0.87, indicating meritorious sampling adequacy (Kaiser, 1974), and Bartlett's test of sphericity was significant, ($\chi^2(28) = 471.54$, $p < 0.001$) suggesting that the data were suitable. Exploratory factor analysis (EFA) was conducted to assess construct validity since the STPIA scale was not previously validated. Based on the scree plot and eigenvalues greater than 1 (see appendices D1 and D2), a 1-factor solution was retained, accounting for 48.69% of the variance. None of the items showed low loadings of less than 0.5 (see appendix D3), resulting in a final subscale of the eight original items.

The Cronbach's alpha of the eight-item STPIA subscale was 0.88, indicating a good degree of internal consistency among the items (Yockey, 2023). The item-total statistics (see appendix D4) did not show that removing items would increase reliability. The means of the individual items ranged from 3.12 to 3.51, with a mean on the total subscale of 26.38(SD = 5.07). The item-total correlation mean was 0.48.

Table 3.6

Summary of the STPIA Subscale

Items	Factor Loadings	Dimensions
I felt pressured to teach in a way that aligned with my cooperating teacher's preferences.	0.76	Implementation
My cooperating teacher supported my decisions about how to adjust instruction during mathematics lessons.	0.75	Implementation
My cooperating teacher allowed me to modify lessons to match my teaching style.	0.74	Planning
I was expected to strictly follow my cooperating teacher's teaching methods.	0.73	Implementation
I felt restricted by my cooperating teacher in the way I taught mathematics, especially when using methods different from their preferred approach.	0.70	Implementation
I felt that I had limited input in how mathematics lessons were taught in the classroom.	0.68	Planning
I felt comfortable teaching mathematics in a way that aligned with my beliefs about best teaching practices.	0.61	Implementation

I had the freedom to incorporate my own ideas into mathematics lesson plans.	0.59	Planning
Cronbach's alpha	0.88	
Item-total correlation mean	0.48	

Note. Only loadings ≥ 0.30 are shown

Developing the Inquiry-Based Mathematics Teaching Efficacy (IBMTE) Subscale

The Mathematics Teaching, Efficacy, and Beliefs Instrument (MTEBI) for preservice teachers includes twenty-one items composed of two subscales: 13-item personal mathematics teaching efficacy (PMTE) and 8-item mathematics teaching outcome expectancy (MTOE) (Enochs, et al., 2000). The instrument is intended to measure a teacher's general mathematics teaching efficacy and does not specifically focus on inquiry-based math instruction. This led to the creation of a more specific subscale focusing on inquiry-based instruction.

The first iteration of the IBMTE subscale consisted of ten items. With permission from one of the authors of the MTEBI, two of the personal mathematics teaching efficacy items were taken and modified to make them specific to an inquiry-based approach. For example, the original item "I understand mathematics concepts well enough to be effective in teaching elementary mathematics" was modified to "I understand mathematics concepts well enough to teach elementary mathematics effectively using inquiry-based instruction." Bandura (2006) states, "Efficacy beliefs differ in generality, strength, and level. People may judge themselves efficacious across a wide range of activity domains or only in certain domains of functioning" (p 313). Therefore, additional items were created focusing on how confident teachers were in their ability to carry out different aspects of IBMI such as understanding various strategies, managing student behavior, and asking effective questions.

Contrary to the MTEBI instrument, Bandura (2006) states that items measuring self-efficacy should use “can do” rather than “will do” since “self-efficacy is concerned with perceived capability” and “Can is a judgment of capability; will is a statement of intention” (p 308). The items on the subscale were written in a way to indicate a measure of capability rather than intention.

As mentioned in the MTEBI instrument, teaching efficacy is comprised of personal teaching efficacy and outcome expectancy. Swars et al. (2006) defines the two components below:

> The first factor, personal teaching efficacy, represents a teacher’s belief in his or her skills and abilities to be an effective teacher. The second factor, teaching outcome expectancy, is a teacher’s belief that effective teaching can bring about student learning regardless of external factors… (p. 307).

After examining pilot data and referring to the literature, the researcher discovered that the initial inquiry-based math efficacy subscale only captured personal teaching efficacy through the development of ten items. Outcome expectancy was being measured through a separate ten-item subscale that the researcher initially called “attitudes toward inquiry-based instruction.” Upon closer evaluation, it was evident that the items measured outcome expectancy rather than attitudes. Therefore, the attitude subscale was eliminated and several of the items were combined with the efficacy scale to thoroughly measure the construct. Below are two examples of items that were originally labeled as attitudes but reflected outcome expectancies:

- Teaching mathematics using inquiry-based instruction will enhance my students’ critical thinking skills.

- Teaching mathematics using inquiry-based instruction will improve my students' long-term understanding of mathematical concepts.

The National Council of Teachers of Mathematics' Teaching and Learning Beliefs Survey (n.d) was used as a guide for developing the outcome expectancy items as part of the efficacy subscale. Additionally, the researcher drew on over ten years of experience in both the elementary and higher education setting to create items that addressed common criticisms and strengths that teachers share regarding inquiry-based teaching methods in math.

The second iteration of the IBMTE subscale included seven items intended to measure teaching efficacy and seven items that measured outcome expectancy. With a total of ($N = 130$) complete responses, Kaiser-Meyer-Olkin measure of sampling adequacy and Bartlett's test of sphericity were used to determine if the data was suitable for exploratory factor analysis (EFA). The KMO value was 0.91, indicating marvelous sampling adequacy (Kaiser, 1974), and Bartlett's test of sphericity was significant, ($\chi^2(78) = 845.92$, $p < 0.001$) suggesting that the data were suitable. Exploratory factor analysis (EFA) was conducted to assess construct validity since the IBMTE subscale was not previously validated. Based on the scree plot and eigenvalues greater than 1 (see appendices E1 and E2), a 2-factor solution was retained, which was anticipated given the two dimensions of math teaching efficacy: personal teaching efficacy and outcome expectancy. Factor 1 seemed to describe outcome expectancy with six items (IBMTE 3, 4, 6, 7, 8, 12) loading at greater than 0.4. While IBMTE-7 was originally written to measure personal teaching efficacy regarding behavior management, it loaded with the outcome expectancy items. IBMTE-7 was retained since positive student behavior could be interpreted as an outcome of inquiry-based math instruction and the loading was greater than 0.5.

The second factor described personal teaching efficacy specific to inquiry-based mathematics instruction with five items (IBMTE 1, 5, 9, 10, 13) loading at greater than 0.4. IBMTE-2 and IBMTE-11 were not retained due to low loadings, less than 0.4, and cross loading on both factors indicating a lack of clarity in the items. Ultimately, two factors were retained with factor 1 accounting for 45.51% of the variance and factor 2 accounting for 52.51% of the variance. Each factor was treated as a separate independent variable during regression analysis. A pattern matrix of the factor loadings can be found in appendix E3.

The Cronbach's alpha of the six-item IBMTOE was 0.86, indicating a good degree of internal consistency among the items (Yockey, 2023). The item-total statistics (see appendix F1) did not show that removing items would increase reliability. The means of the individual items (see appendix F2) ranged from 2.98 to 3.30, with a mean on the total subscale of 18.48(SD = 3.59). The item-total correlation mean was 0.51.

The Cronbach's alpha for the 5-item personal inquiry-based math teaching efficacy subscale was 0.84, indicating a good degree of internal consistency among the items (Yockey, 2023). The item-total statistics (see appendix F3) did not show that removing items would increase reliability. The means of the individual items (see appendix F4) ranged from 2.92 to 3.24, with a mean on the total subscale of 15.75(SD = 2.88). The item-total correlation mean was 0.52.

Table 3.7

Summary of Inquiry-Based Math Teaching Outcome Expectancy (IBMTOE) Subscale

Items	Factor Loadings	Dimensions
My use of inquiry-based instruction can improve students' problem-solving skills, even if they struggle initially.	0.89	Student learning
	0.77	Engagement

My use of inquiry-based instruction can increase motivation in students who are usually unengaged.		
My use of inquiry-based instruction can encourage perseverance in problem-solving, even for students who usually give up quickly.	0.73	Engagement
I can effectively manage student behavior during an inquiry-based lesson.	0.55	Engagement
My use of inquiry-based instruction can support student learning, even when they lack strong foundational math skills.	0.50	Student learning
My use of inquiry-based instruction can help all students develop conceptual understanding regardless of their current level of math proficiency.	0.47	Student learning
Cronbach's alpha	0.86	
Item-total correlation mean	0.51	

Note. Only loadings ≥ 0.30 are shown

Table 3.8

Summary of Personal Inquiry-Based Math Teaching Efficacy (PIBMTE) Subscale

Items	Factor Loadings	Dimensions
I can effectively ask open-ended questions that help assess my students' understanding and identify misconceptions as they explore problems.	0.83	Assessment
I can effectively adapt my questioning based on the strategies students use to deepen their understanding of the problem.	0.78	Questioning
I can effectively facilitate student collaboration during open-ended problem-solving tasks.	0.72	Engagement
I can teach mathematics concepts effectively using an inquiry-based approach.	0.50	Instruction
I understand mathematics concepts well enough to teach elementary mathematics effectively using an inquiry-based approach.	0.47	Content understanding
Cronbach's alpha	0.84	
Item-total correlation mean	0.52	

Note. Only loadings ≥ 0.30 are shown

In summary, the questionnaire included five subscales measuring one dependent variable and four independent variables. Inquiry-based math teaching efficacy was decomposed into two separate independent variables in subsequent analysis. Items were dropped that loaded less than 0.4 on or cross-loaded on multiple factors. Additionally, frameworks and dimensions of each scale were considered when making decisions about which items to retain. Below is a table summarizing the five subscales used in the analysis.

Table 3.9

Summary of Subscales Used in Analysis

Scale	Items	Cronbach's Alpha	Item-Total Correlation Mean	Frameworks
Student Teacher Inquiry-Based Math Instruction	4	0.65	0.31	Math Teaching Practices, Standards of Math Practice
Cooperating Teaching Inquiry-Based Math Instruction	4	0.74	0.42	Math Teaching Practices, Standards of Math Practice
Student Teachers' Perceived Instructional Autonomy	8	0.88	0.48	Instructional Autonomy
Personal Inquiry-Based Teaching Efficacy	5	0.84	0.52	Math Teaching Efficacy
Inquiry-Based Math Teaching Outcome Expectancy	6	0.86	0.51	Math Teaching Efficacy

Data Analysis

Research Questions and Statistical Methods

The study aims to address two research questions:

> **RQ1:** To what extent is elementary student teachers' self-reported implementation of inquiry-based mathematics instruction associated with their perceptions of math teaching efficacy, instructional autonomy, and cooperating teachers' implementation of inquiry-based instruction?

Multiple regression analysis was used to determine how much variance in the dependent variable, student teachers' reporting of their implementation of inquiry-based math instruction (STIBMI) is explained by the independent variables and the strength and direction of those relationships. This analysis is appropriate as "the multiple regression procedure is used when two or more variables are used to predict one criterion variable" (Ravid, 2020, p. 118). Because the inquiry-based mathematics teaching efficacy scale loaded onto two distinct factors (personal teaching efficacy and outcome expectancy) each was used a separate independent variable during data analysis. Bandura (1997) describes efficacy beliefs and outcome expectancies as separate, but related components, supporting the decision to use them as separate variables in analysis. After all, a preservice teacher may feel confident in their ability to implement IBMI but may not believe that it will lead to positive outcomes, or vice versa. By treating these as separate variables, the study can gain a more nuanced understanding of inquiry-based math teaching efficacy. Existing efficacy scales also suggest computing the scores separately in the scoring instructions (Enochs et al., 2000; Enochs & Riggs, 1990) and previous studies have also treated each component as separate variables in analysis (Koutsianou & Emvalotis, 2019; Siwatu, 2007). The following regression equation represents the model used to estimate the relationship between the predictors and the student teachers' implementation of inquiry-based mathematics instruction.

$$Y_i = \beta_0 + \beta_1 CTIBMI_i + \beta_2 STPIA_i + \beta_3 PIBMTE_i + \beta_4 IBMTOE_i + \epsilon_i$$

Where Y_i represents the implementation of inquiry-based mathematics instruction for participant *i*; CTIBMI = cooperating teacher implementation of inquiry-based math instruction; STPIA = student teachers perceived instructional autonomy; PIBMTE = personal inquiry-based math teaching efficacy; IBMTOE = inquiry-based math teaching outcome expectancy; and e_i is the residual error term for participant *i*.

> **RQ2:** To what extent does the relationship between elementary student teachers' implementation of inquiry-based mathematics instruction and math teaching efficacy differ by their perceptions of instructional autonomy and cooperating teachers' implementation of inquiry-based instruction?

To test the second research question, moderation regression analysis was used to determine whether the relationship between STIBMI and each of the efficacy factors differed by each of the cooperating teacher factors (STPIA and CTIBMI). One interaction term was added to the original equation for each of the four separate regression models that were used. The first explored whether the relationship between STIBMI and PIBMTE differed by STPIA (PIBMTE x STPIA). The second explored whether the relationship between STIBMI and IBMTOE differed by STPIA (IBMTOE x STPIA). The third explored whether the relationship between STIBMI and PIBMTE differed by CTIBMI (PIBMTE x CTIBMI). The fourth explored whether the relationship between STIBMI and IBMTOE differed by CTIBMI (IBMTOE x CTIBMI).

Before running the model, the independent and moderating variables were centered by subtracting the mean of all scores for that variable from the total score. This allowed the *b* values to be more easily interpreted since the *b*s can "represent the effect of the predictor when the other predictor is at its mean value" (Field, 2018, p. 362). Interaction variables were then created in SPSS for each of the four hypotheses. These variables were used to run an initial regression analysis to test whether the relationship between personal inquiry-based math teaching efficacy and implementation of IBMI differed based on cooperating teacher implementation. The results were compared to an output using the PROCESS tool, showing that both methods yield the same results. PROCESS was used for the remaining moderation analyses.

Assumptions and Description of Data

Regression analysis includes assumptions regarding independence of observations, linearity, homoscedasticity, multicollinearity, and outliers. While these assumptions cannot be tested, the data was examined to determine whether it was favorable for analysis.

The assumption of independence of observations between participants was met since the survey was emailed to participants individually and they did not have an opportunity to influence one another. The variables were measured on a continuous scale by summing the values of each item to create a total score.

Linearity was examined using scatterplots of each independent variable and the dependent variable (see appendices G1-G4). The relationship between elementary student teachers perceived instructional autonomy and their implementation of inquiry-based math instruction showed a weak positive linear relationship ($R^2 = 0.06$). The relationship between both personal teaching efficacy ($R^2 = 0.19$) and outcome expectancy ($R^2 = 0.20$) showed moderate positive linear relationships. The strongest linear relationship was between the cooperating teacher's modeling of inquiry-based math instruction and the student teacher's implementation of this approach ($R^2 = 0.31$).

Normality of residuals was examined using a histogram (see appendix G5) and P-P plot (see appendix G6), both of which indicated normality among the residuals. A scatterplot that examined the standardized residuals and standardized predicted values (see appendix G7) showed a random pattern, indicating that "the variances on the dependent variable are equal in population for all possible combinations of levels of the independent variables" (Yockey, 2023, p. 187). All models were estimated with heteroskedasticity-consistent standard errors.

Boxplots (see appendix G8) showed several mild outliers in the data. Regression diagnostics (see appendix G9) including standardized and studentized residuals, Cook's Distance, and Leverage values were used to determine whether the outliers would influence the results. One response showed a high leverage value but met the criteria for the residuals and Cook's Distance. Therefore, all the responses were retained in data analysis.

SPSS was used to produce all statistical analyses. Descriptive statistics including the means, standard deviation, and range scores for each variable were calculated and utilized to identify potential errors in the data (Cresswell, 2014). Ten items were reverse coded prior to running any statistical analyses. After completing data preparation, factor analysis was run to assess the dimensionality of each survey scale and Cronbach's alpha coefficient was used to assess scale reliability (Artino et al., 2014). A two-tail test with alpha levels set at 0.05 were used for all statistical analyses, meaning that a p value of less than 0.05 indicated that the results were significant and unlikely to occur by chance.

Summary

Elementary student teachers participated in a study to examine the potential relationships between personal and cooperating teacher variables and the extent to which the student teachers implement inquiry-based math instruction based on self-reports. A questionnaire composed of five subscales was developed with input from mathematics education professors and fellow math education doctoral students. The instrument was piloted and revised prior to data collection. Elementary student teachers from accredited universities across five states were sent the Qualtrics questionnaire via email in April and May of 2025. Data analysis included exploratory factor analysis and Cronbach's alpha reliability testing to establish construct validity and reliability for each subscale. Multivariate correlation analysis, multiple regression analysis, and moderation analysis examined potential relationships between the variables in the study.

Chapter 4 - Findings

Presentation of Data

Descriptive Statistics for all Study Variables

Participants (N = 130) provided information regarding their personal characteristics and teaching placement. Most participants were female (96.2%) between the ages of 18-23 years old (85.4%). Most taught in self-contained classrooms (76.2%) teaching all core subjects to the same group of students, with a class size of 16-25 students. Nearly a third (30.8%) reported that they taught more than fifty mathematics lessons during their student teaching semester.

Table 4.1

Demographic Characteristics of Participants

Characteristic	Category	*n*	%
Gender	Male	4	3.1
	Female	125	96.2
	Non-binary	1	.8
District Type	Urban	20	15.4
	Suburban	56	43.1
	Rural	36	27.7
	Unsure	18	13.8
Classroom Structure	Self-Contained	99	76.2
	Departmentalized	28	21.5
	Other	3	2.3
Class Size	Less than 10 students	4	3.1
	11-15 students	17	13.1
	16-20 students	60	46.2
	21-25 students	42	32.3
	26 or more students	7	5.4

Descriptive statistics for each of the 5 variables are displayed in the table below. Possible scores for the student teacher inquiry-based instruction (STIBMI) and student teachers' reporting of their cooperating teachers' implementation of inquiry-based instruction (CTIBMI) subscales ranged from 4-16. Possible scores on the student teacher perceived instructional autonomy (STPIA) were 8-32, personal inquiry-based math teaching efficacy (PIBMTE) were 5-20 and inquiry-based math teaching outcome expectancy (IBMTOE) were 6-24. Because the summed scores include a different number of scale items, the means should not be compared to one another.

Table 4.2

Descriptive Statistics for Study Variables

Variable	*n*	Min	Max	*M*	*SD*	Items on Scale
STIBMI	130	5.00	16.00	11.00	2.20	4
CTIBMI	130	4.00	16.00	10.43	2.60	4
STPIA	130	13.00	32.00	26.38	5.07	8
PIBMTE	130	8.00	20.00	15.75	2.88	5
IBMTOE	130	6.00	24.00	18.48	3.59	6

Note. M=Mean *SD*=Standard Deviation

Correlation Matrix of Key Variables

Bivariate correlation showed that, when examined separately, all the independent variables had a significant positive relationship with the dependent variable. Student teachers' reporting of their cooperating teacher's implementation of inquiry-based math instruction (IBMI) had the strongest relationship with their own implementation, $r(128) = 0.55$, $p < 0.01$. The relationship between student teachers' implementation of IBMI and their perceived instructional autonomy is also significantly correlated, but with a smaller coefficient, $r(128) = 0.24$, $p < 0.01$.

Table 4.3

Correlation Table

	CTIBMI	STPIA	PIBMTE	IBMTOE
STIBMI	0.55^{**}	0.24^{**}	0.43^{**}	0.44^{**}
CTIBMI		0.47^{**}	0.31^{**}	0.28^{**}
STPIA			0.26^{**}	0.21^{*}

PIBMTE	0.66**

Note. Pearson's *r* used for correlations

**Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Results for RQ1: Predictors of Student Teachers' Implementation of Inquiry-Based Instruction

Multiple Regression Analysis of Personal Teaching Efficacy, Outcome Expectancy, Perceived Autonomy, and Cooperating Teacher Implementation

A multiple regression was conducted predicting elementary student teachers' self-reported implementation of inquiry-based mathematics instruction from the following four independent variables: elementary student teachers perceived instructional autonomy, personal inquiry-based math teaching efficacy, outcome expectancy, and student teachers' reporting of their cooperating teachers' implementation of inquiry-based math instruction. Overall, the regression was significant, $F(4, 125) = 24.90$, $p < 0.001$, $R^2 = 0.41$, indicating that 41% of the variance in implementation was explained by the four predictors.

Of the predictors investigated, student teachers' reporting of their cooperating teachers' implementation of IBMI ($\beta = 0.48$, $t(125) = 5.64$, $p < 0.001$) and elementary student teachers' inquiry-based mathematics teaching outcome expectancy ($\beta = 0.21$, $t(125) = 2.22$, $p < 0.05$) were significant. Student teachers perceived instructional autonomy ($\beta = -0.07$, $t(125) = -0.75$, $p = 0.45$) and personal inquiry-based mathematics teaching efficacy ($\beta = 0.17$, $t(125) = 1.58$, $p = 0.12$) were not significant predictors.

Table 4.4
Multiple Regression Coefficients

Predictor	*B*	*SE B*	*β*	*t*	*p*	95% CI Lower	95% CI Upper
CTIBMI	0.40	0.07	0.48	5.64	< 0.001	0.26	0.54
STPIA	-0.03	0.04	-0.07	-0.75	0.45	-0.11	0.05
PIBMTE	0.13	0.08	0.17	1.58	0.12	-0.03	0.29
IBMTOE	0.13	0.05	0.21	2.22	< 0.05	0.01	0.24

Note. Standard errors are HC3 robust

Note. R = 0.64, $R^2 = 0.41$, $F(4, 125) = 24.90$, $p < 0.001$

Results for RQ2: Moderating Effects on the Relationship between Teaching Efficacy and Student Teachers' Implementation of Inquiry-Based Instruction

Effect of Cooperating Teacher Implementation on the Personal Teaching Efficacy-Student Teacher Implementation Relationship

A moderation analysis was conducted to determine whether the relationship between elementary student teachers' implementation of inquiry-based mathematics instruction and their personal teaching efficacy differed by the extent to which they reported their cooperating teacher using inquiry-based instruction. The overall model was significant, $F(5, 124) = 20.16$, $p < 0.001$, $R^2 = 0.43$, indicating that the set of predictors explained approximately 43% of the variance in implementation. Both student teachers' reports of their cooperating teachers' implementation of IBMI ($b = 0.42$, $p < 0.001$) and outcome expectancy ($b = 0.13$, $p < 0.05$) were significant predictors. However, personal teaching efficacy ($b = 0.10$, $p = 0.20$) and perceived autonomy ($b = -0.04$, $p = 0.36$) were not significant. Additionally, the interaction between personal efficacy and cooperating teacher implementation was not significant ($b = -0.03$, $p = 0.07$), indicating that the relationship between personal efficacy and implementation of IBMI did not differ by cooperating teachers' implementation of IBMI.

Table 4.5

Summary of Interaction Analysis: PIBMTE x CTIBMI

Predictor	*B*	*SE*	*t*	*p*	95% CI lower	95% CI Upper
PIBMTE	0.10	0.08	1.29	0.20	-0.06	0.26
CTIBMI	0.42	0.07	5.94	< 0.001	0.28	0.56
IBMTOE	0.13	0.06	2.44	< 0.05	0.02	0.24
STPIA	-0.04	0.04	-0.92	0.36	-0.12	0.04
PIBMTE x CTIBMI	-0.03	0.02	-1.83	0.07	-0.07	0.00

Note. Model $R^2 = 0.43$, $F(5, 124) = 20.16$, $p < 0.001$

Effect of Perceived Instructional Autonomy on the Personal Teaching Efficacy-Student Teacher Implementation Relationship

A moderation regression analysis was conducted to determine whether the relationship between elementary student teachers' implementation of inquiry-based mathematics instruction and their personal teaching efficacy differed by their perceived instructional autonomy. The overall model was significant, $F(5, 124) = 20.09$, $p < 0.001$, $R^2 = 0.42$, indicating that the set of predictors explained approximately 42% of the variance in implementation. Student teachers' reports of their cooperating teachers' implementation of IBMI ($b = 0.40$, $p < 0.001$) and outcome expectancy ($b = 0.13$, $p < 0.05$) were both significant predictors. Personal teaching efficacy ($b = 0.12$, $p = 0.18$) and perceived instructional autonomy ($b = -0.03$, $p = 0.42$) were not significant. Additionally, the interaction between personal efficacy and perceived instructional autonomy was not significant ($b = -0.01$, $p = 0.43$), indicating that the relationship between personal efficacy and implementation of IBMI did not differ by student teacher's perceived instructional autonomy.

Table 4.6

Summary of Interaction Analysis: PIBMTE x STPIA

Predictor	*B*	*SE*	*t*	*p*	95% CI lower	95% CI Upper
PIBMTE	0.12	0.09	1.36	0.18	-0.05	0.28
STPIA	-0.03	0.04	-0.80	0.42	-0.12	0.05
CTIBMI	0.40	0.07	5.64	< 0.001	0.26	0.55
IBMTOE	0.13	0,06	2.23	< 0.05	0.01	0.25
PIBMTE x STPIA	-0.01	0.01	-0.79	0.43	-0.03	0.01

Note. Model $R^2 = 0.42$, $F(5, 124) = 20.09$, $p < 0.001$

Effect of Cooperating Teacher Implementation on the Outcome Expectancy-Student Teacher Implementation Relationship

A moderation analysis was conducted to determine whether the relationship between elementary student teachers' implementation of inquiry-based mathematics instruction and their outcome expectancy differed by the extent to which they reported their cooperating teacher using inquiry-based instruction. The overall model was significant, $F(5, 124) = 21.38$, $p < 0.001$, $R^2 = 0.42$, indicating that the set of predictors explained approximately 42% of the variance in implementation. Student teachers' reports of their cooperating teacher implementing IBMI ($b = 0.42$, $p < 0.001$) and outcome expectancy ($b = 0.11$, $p < 0.05$) were significant predictors. However, perceived instructional autonomy ($b = -0.03$, $p = 0.41$) and personal teaching efficacy ($b = 0.13$, $p = 0.11$) were not significant. Additionally, the interaction between outcome expectancy and cooperating teacher implementation was not significant ($b = -0.02$, $p = 0.10$), indicating that the relationship between outcome expectancy and implementation of IBMI did not differ by cooperating teacher implementation of IBMI.

Table 4.7

Summary of Moderation Analysis: Outcome Expectancy x CT Inquiry-Based Math Instruction

Predictor	*B*	*SE*	*t*	*p*	95% CI lower	95% CI Upper
IBMTOE	0.11	0.05	1.98	< 0.05	0.00	0.22
CTIBMI	0.42	0.07	5.80	< 0.001	0.28	0.56
PIBMTE	0.13	0.08	1.62	0.11	-0.03	0,30

STPIA	-0.03	0.04	-0.82	0.41	-0.12	0.05
IBMTOE x CTIBMI	-0.02	0.01	-1.67	0.10	-0.04	0.00

Note. Model $R^2 = 0.42$, $F(5, 124) = 21.38$, $p < 0.001$

Effect of Perceived Instructional Autonomy on the Outcome Expectancy-Student Teacher Implementation Relationship

A moderation analysis was conducted to determine whether the relationship between elementary student teachers' implementation of inquiry-based mathematics instruction and their outcome expectancy differed by their perceived instructional autonomy. The overall model was significant, $F(5, 124) = 20.58$, $p < 0.001$, $R^2 = 0.43$, indicating that the set of predictors explained approximately 43% of the variance in implementation. Student teachers' reports of their cooperating teachers' implementation of IBMI ($b = 0.41$, $p < 0.001$) and outcome expectancy ($b = 0.12$, $p < 0.05$) were significant predictors. Perceived instructional autonomy ($b = -0.03$, $p = 0.43$) and personal teaching efficacy ($b = 0.12$, $p = 0.15$) were not significant. Additionally, the interaction between outcome expectancy and perceived instructional autonomy was not significant ($b = -0.01$, $p = 0.14$), indicating that the relationship between outcome expectancy and implementation of IBMI did not differ by student teacher's perceived instructional autonomy.

Table 4.8

Summary of Interaction Analysis: IBMTOE x STPIA

Predictor	*B*	*SE*	*t*	*p*	95% CI lower	95% CI Upper
IBMTOE	0.12	0.06	2.20	< 0.05	0.01	0.24
STPIA	-0.03	0.04	-0.79	0.43	-0.11	0.05
CTIBMI	0.41	0.07	5.72	< 0.001	0.27	0.55
PIBMTE	0.12	0.08	1.45	0.15	-0.04	0.28
IBMTOE x STPIA	-0.01	0.01	-1.48	0.14	-0.03	0.00

Note. Model $R^2 = 0.43$, $F(5, 124) = 20.58$, $p < 0.001$

Summary of Findings

A sample of 130 elementary student teachers was used in several analyses to examine the relationship between elementary student teachers' self-reported implementation of inquiry-based math instruction and four independent variables: perceived instructional autonomy, personal inquiry-based math teaching efficacy, inquiry-based math outcome expectancy, and cooperating teacher implementation of inquiry-based instruction.

In the bivariate correlations, each independent variable showed a statistically significant positive relationship with student teachers' implementation of inquiry-based math instruction, with cooperating teacher implementation having the strongest relationship and perceived instructional autonomy having the weakest. A multiple regression analysis showed that the model was significant when it included all four independent variables; however, only cooperating teacher implementation and outcome expectancy were statistically significant predictors when controlling for the other variables.

Four separate interaction analyses were used to examine whether the relationship between two components of math teaching efficacy and elementary student teacher's implementation of inquiry-based math instruction differed by their perception of instructional autonomy and cooperating teacher implementation. All four models were significant overall, and cooperating teacher implementation and outcome expectancy were significant predictors across all models. However, none of the interaction terms reached statistical significance, indicating that the relationship between efficacy and student teacher implementation of IBMI did not differ by their perceived instructional autonomy or cooperating teacher implementation.

Chapter 5 - Discussion

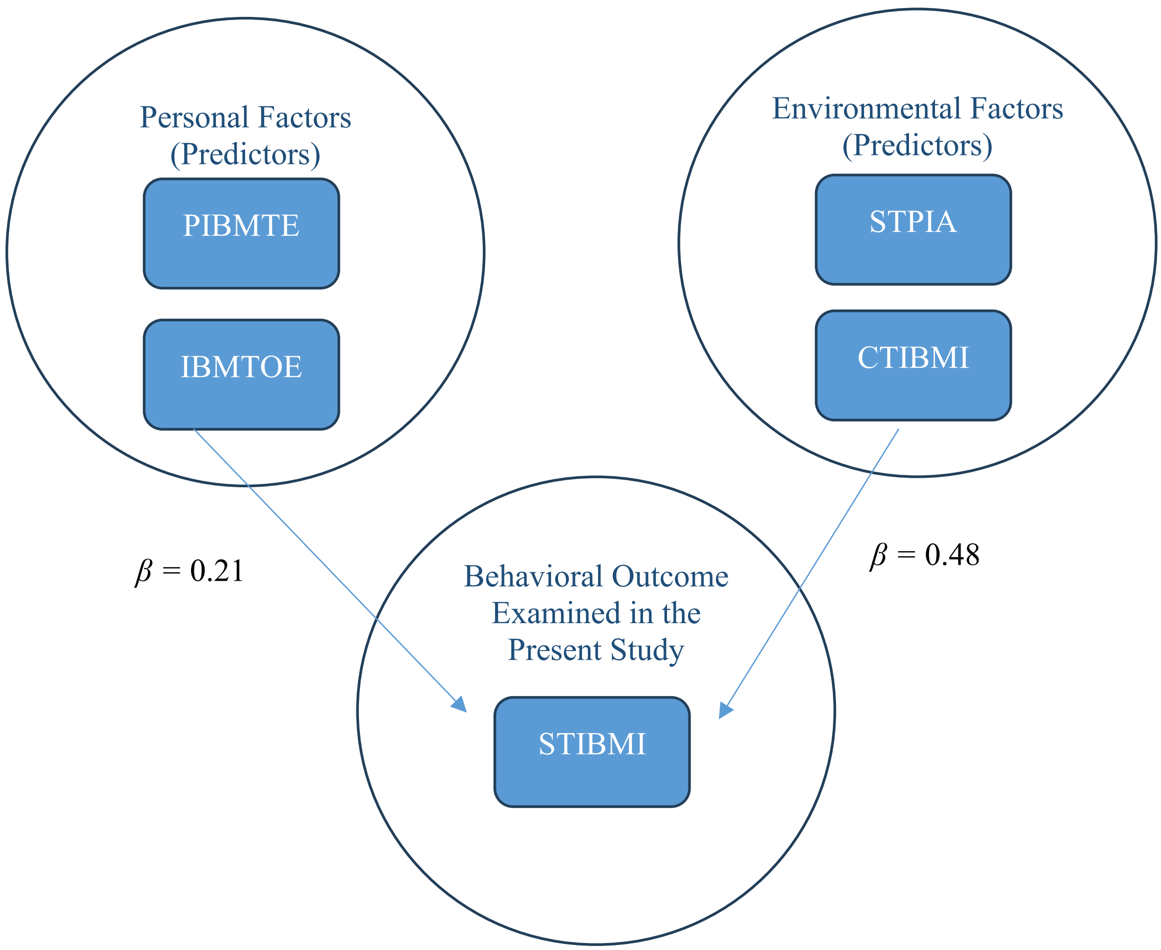
Introduction

The purpose of the study was to examine the relationship between four independent variables- elementary student teachers perceived instructional autonomy (STPIA), personal inquiry-based math teaching efficacy (PIBMTE), inquiry-based math outcome expectancy (IBMTOE), and cooperating teacher implementation of inquiry-based instruction (CTIBMI)- and elementary student teacher' self-reported implementation of inquiry-based math instruction (STIBMI). The variables were chosen based on Bandura's (1989) social cognitive theory (SCT) framework which states that behavior is driven by both environmental and personal factors. Cooperating teacher implementation and student teachers perceived autonomy represented environmental factors that directly relate to the cooperating teacher in the field placement while personal teaching efficacy and outcome expectancy represent personal factors related to the behavior of inquiry-based instruction. Pearson's correlation and regression analyses were used to examine relationships.

Pearson's coefficients showed positive correlations between all four variables and the outcome of interest. However, the regression analysis showed that only student teachers' reporting of their cooperating teachers' implementation of IBMI and student teachers' outcome expectancy of inquiry-based math instruction were significant after controlling all other variables. In other words, CTIBMI and IBMTOE are significant predictors of STIBMI, even after controlling perceived efficacy and instructional autonomy. Moderation analysis showed that none of the effect terms were statistically significant, indicating that the relationship between efficacy and student teacher implementation of IBMI did not differ by cooperating teacher implementation or student teacher perceived instructional autonomy. Table illustrates the connection between the significant variables in the study and social cognitive theory domains.

Figure 5.1

Social Cognitive Theory and Results of Multiple Regression Analysis



Note. Arrows represent statistically significant standardized regression coefficients (*β)* from the multiple regression model.

Interpretation of Findings

Examining Means on the Variables

Means of Reported Inquiry-Based Math Instruction for Student Teachers and Cooperating Teachers

The mean scores on each scale provide insight into whether IBMI is being used by student teachers and cooperating teachers in the field. The student teachers' self-reported implementation of IBMI (M = 11.00) indicates a moderate use of this instructional approach with possible scores ranging from 5 to 16. Student teachers reported that their cooperating teachers also moderately implemented inquiry-based instruction (M =10.43). This seems to illustrate that both student teachers and cooperating teachers are using practices that align with inquiry-based instruction, but they may not implement the model to its fullest potential. Mean scores for individual items on the scale showed that student teachers reported implementing IBMI with means ranging from 2.28-3.00, while their cooperating teachers were rated slightly lower with means ranging from 2.24-2.85. Considering that a 2 indicates use in *a few lessons* and a 3 reflects use in *most lessons*, the results suggest that student teachers are observing inquiry-based practices being implemented by cooperating teachers in at least some lessons. While the frequency of observations does not yet reach the level of "most lessons," this may indicate a slight shift toward IBMI compared to earlier findings (Frykholm, 1996; Harper & Daane, 1998; Ronfeldt & Grossman, 2008).

Means of Reported Inquiry-Based Mathematics Teaching Efficacy

The mean scores also provide insight into student teachers' efficacy when it comes to teaching using an inquiry-based approach. This is particularly interesting given that previous instruments have measured general math teaching efficacy (Enochs, et al., 2000) and levels of efficacy likely change depending on how the instructional approach is being used (Smith, 1996). This data shows that student teachers report moderately high levels of personal teaching efficacy (M = 15.75, possible scores 5-20) as well as moderately high levels of outcome expectancy (M = 18.48, possible scores 6-24) when considering inquiry-based instruction in mathematics.

The results are encouraging considering that previous studies have shown that preservice teachers enter educator preparation programs (EPP) with low confidence in their math abilities and a more traditional view of mathematics (Althauser, 2018; Cassel & Vincent, 2011; Frykholm, 1996; Harper & Daane, 1998; Smith, 1996; Swars et al., 2006). The results indicate preservice teachers' confidence with teaching mathematics is increasing and they also begin to see inquiry-based practices as worthwhile during their teacher training, conclusions that support the idea that EPPs can positively influence preservice teachers' teaching efficacy (Boyacı & Erdamar 2023; Richardson & Liang, 2008).

Means of Reported Perceived Instructional Autonomy of Student Teachers

Examining the mean score for student teachers perceived instructional autonomy (M = 26.38, possible scores 8-32) indicates that they perceive a moderate level of instructional autonomy from their cooperating teacher while student teaching. The means on individual items ranged from 3.11-3.51 indicating responses between *sometimes true* and *mostly true* when asked about the level of freedom they felt to plan and implement mathematics instruction. Student teachers find themselves in imposed environments (Bandura, 2012), so even if they perceive autonomy from their cooperating teacher, they still must teach within an environment with constraints such as pacing pressures, state standards, curriculum expectations, and administrative expectations, factors that also influence perceived autonomy of classroom teachers (Narayanan et al., 2024). Additionally, cooperating teachers often view themselves as models, mentors, and guides (Weasmer & Woods, 2003) and thus may remain in control of some instructional decisions.

Narayanan et al. (2024) found that elementary teachers and teachers who received scripted lesson plans through district-selected curriculum reported lower levels of instructional autonomy, and elementary teachers were more likely to receive scripted lesson plans compared to high school teachers. The elementary student teachers in this study reported moderate levels of instructional autonomy, and this difference could be due to the focus on the student teachers' autonomy related to the cooperating teacher rather than more general instructional autonomy explored in the previous study. While this study did not ask participants about whether their district utilized scripted lesson plans, it would be interesting to examine the "trickledown effect" of this variable on student teachers' autonomy.

Examining RQ1: Predictors of Student Teachers' Implementation of Inquiry-Based Instruction

RQ1: To what extent is elementary student teachers' self-reported implementation of inquiry-based mathematics instruction associated with their perceptions of math teaching efficacy, instructional autonomy, and cooperating teachers' implementation of inquiry-based instruction?

Significance of the Overall Regression Model

Because each of the independent variables was selected based on previous literature, it was not surprising that correlations between all four independent variables and elementary student teacher's implementation of IBMI were statistically significant. It also was not surprising that the regression model, with all the variables included, was significant. This result aligns with the study's framework, social cognitive theory, since the variables represent the interactions between personal, behavior, and environmental factors (Schunk, 2012). The effect size of the model is considered large, indicating that the four independent variables accounted for 41% of the variance in elementary student teachers' implementation of IBMI. While the selected variables account for a significant amount of variance, 59% is still unaccounted for in this study. Additional factors such as standards, curriculum, state and district policies, standardized testing, and building culture likely contribute to student teachers' implementation of IBMI.

Examining Cooperating Teacher Implementation of Inquiry-Based Math Instruction as a Predictor

The results of the regression model showed that cooperating teacher implementation of inquiry-based instruction was the strongest predictor of student teachers' implementation of inquiry-based instruction. This result was both statistically and practically significant when considering that the mean score on the CTIBMI was 10.43 out of 16 possible, and even slight increases in observed modeling were associated with significant increases in STIBMI scores. For example, an increase in 8 points on the CTIBMI scale---indicating a shift from infrequent to frequent modeling---results in an increase of 3.22 points in STIBMI. Given that the standard deviation for STIBMI is 2.20, this indicates about 1.5 standard deviations of change supporting previous studies showing that the cooperating teacher is the biggest influence on student teachers (Anderson, 2009; Frykholm, 1996; Peterson & Williams, 2008; Whitney et al., 2002; Yee, 1969; Zeichner, 1980) and that many preservice teachers indicate that their teaching mirrors that of their cooperating teacher (Anderson, 2009; Frykholm, 1996). The finding also aligns with observational learning, a key concept in SCT, which posits that learners "are more likely to attend to models who have status and credibility"—in this case, the cooperating teacher (Schunk, 2012). This finding suggests that, in the context of student teachers, observational learning is more impactful than the other environmental and personal factors explored in this study.

Although CTIBMI was the strongest predictor of STIBMI, the study did not investigate student teachers' perceptions of how effectively their cooperating teacher implemented IBMI, nor whether they believed it resulted in positive student learning outcomes. Bandura (2014) explains that "people are motivated by the successes of others who are similar to themselves" and "people are more likely to exhibit modeled behavior if it results in valued outcomes…" (p. 24). Although future research might investigate these additional dimensions, the SCT framework helps explain why outcome expectancy also proved to be a significant predictor in the regression model.

Examining Inquiry-Based Math Teaching Outcome Expectancy as a Predictor

Outcome expectancy was also a statistically significant predictor of student teachers reporting of their implementation of IBMI. The mean score on the IBMTOE was 18.48 out of 24 possible. An increase in 10 points on the IBMTOE scale results in an increase of 1.29 points on the STIBMI scale, indicating about 0.59 standard deviations of change. This indicates that although outcome expectancy contributes to implementation, its practical influence is more limited compared to the stronger environmental factor of cooperating teacher implementation. This supports Bandura's (2014) conclusion that "reciprocal causation does not mean that the different sources of influence are of equal strength. Some may be stronger than others" (p. 2). While this study does not suggest causation, it does support the idea that the variables examined differ in their influence on student teachers' implementation of IBMI.

Outcome expectancy as a significant predictor differs from a previous study where preservice teachers reported high teaching efficacy but only modest outcome expectancy (Byrd

& Giles, 2023). It is worth noting that in the previous study, the participants completed the MTEBI questionnaire prior to internships and only descriptive statistics were utilized in analysis. The present study examined personal efficacy and outcome expectancy during a clinical experience, which could explain the differing results from the prior study. Additionally, the significance of outcome expectancy in the present study seems to fit with the interaction between environmental influences and personal characteristics explained in SCT (Bandura, 2014). Observing a cooperating teacher using inquiry-based practices could communicate to a student teacher that the approach is effective and worthwhile, which is the foundation of outcome expectancy. In other words, a student teacher who sees their cooperating teacher implementing this type of instruction (environmental factor) may conclude that the approach will lead to positive outcomes (personal characteristic), which leads to their own use of the approach (behavior) despite their personal confidence with implementation. Because student teachers are considered novices in highly structured environments, their belief that the method works may outweigh their personal confidence in implementation.

Examining Personal Inquiry-Based Math Teaching Efficacy as a Predictor

Personal teaching efficacy was not a significant predictor in the regression model. This could be due to the overlap between personal efficacy and outcome expectancy and would be expected considering that these are two components of inquiry-based math teaching efficacy. It's likely that the overlap with outcome expectancy prevented personal efficacy to contribute new variance to the model. Personal efficacy and outcome expectancy were moderately correlated with one another supporting this idea. Additionally, this result may indicate that student teachers' personal confidence in their teaching ability is not as important as believing that a particular approach is effective. Takunyaci (2021) found that there was a significant difference in personal math teaching efficacy among teachers with 11 or more years of experience compared to teachers with 0-5 years of experience. Perhaps novice teachers recognize that their confidence with teaching will likely increase with experience and instead focus on learning effective strategies that they see as leading to effective outcomes.

Examining Student Teachers Perceived Instructional Autonomy as a Predictor

Perceived instructional autonomy was not statistically significant in the regression model suggesting that, by itself, this environmental factor does not predict student teachers' implementation of IBMI. This shows that simply having freedom to plan and implement lessons does not predict implementation of IBMI, which also aligns with reciprocal determinism outlined in SCT. Because personal, environmental, and behavior factors interact to influence future behavior, it is possible that having autonomy is not enough without the interaction of a personal factor such as high personal teaching efficacy or a strong environmental factor, such as an inquiry-based curriculum.

The result also supports the claim that "autonomy should not be considered simplistically as 'good' or 'bad'" since some teachers enjoy the freedom to create lessons with little oversight while others find it overwhelming (Narayanan et al., 2024, p. 29). The student teachers in the study may find autonomy overwhelming as they attempt to navigate different personal and environmental factors while also establishing themselves within an established classroom environment. Perhaps the student teachers felt they had instructional autonomy from their cooperating teacher, but stress, personal limitations or other demands prevented the behavior. This would support the idea that emotional factors can also influence behavior (Bandura, 2014).

Furthermore, in the regression model, it is possible that after accounting for modeling, efficacy, and outcome expectancy, perceived autonomy did not contribute enough unique variance. This seems likely since observing effective teaching practices can contribute to higher self-efficacy in preservice teachers (Kandali, 2017). It could also be an indication of an indirect effect. Perhaps student teachers who perceived more autonomy also had stronger efficacy or were placed with teachers who were implementing IBMI. Rondfeldt et al. (2013) found a similar situation where student teachers who experienced more autonomy also reported stronger teaching efficacy and a greater sense of preparedness. Further investigation into how perceived autonomy relates to other components is needed to capture its influence on the implementation of IBMI.

Examining RQ2: Moderating Effects on the Relationship between Teaching Efficacy and Student Teachers' Implementation of Inquiry-Based Instruction

RQ2: To what extent does the relationship between elementary student teachers' implementation of inquiry-based mathematics instruction and math teaching efficacy differ by their perceptions of instructional autonomy and cooperating teachers' implementation of inquiry-based instruction?

The second research question was intended to be exploratory in nature. The reciprocal nature of SCT and the interactions between personal, environmental, and behavior factors seemed to indicate that interaction effects may be present among the variables. The researcher hypothesized that environmental factors, due to the structured context of student teaching and prior research identifying the CT as the strongest influence on STs (Anderson, 2009; Frykholm, 1996; Peterson & Williams, 2008; Whitney et al., 2002; Yee, 1969; Zeichner, 1980), would alter the relationship between personal factors and IBMI. However, none of the interaction terms were significant in the four moderation regression models.

The results indicate that there is not sufficient evidence to show that the relationship between STIBMI and either of the efficacy components differs by the student teachers' reports of their cooperating teachers' implementation of IBMI or their perceived instructional autonomy. While it is possible that moderation does not exist in these relationships, it is also possible that there is insufficient statistical power due to inadequate sample size. Additionally, the measures may lack sufficient nuance to capture significant effects. Additionally, Bandura (2014) notes that reciprocal influences do not always occur simultaneously and "it takes time for a causal factor to exert its influence and activate reciprocal influences" (p. 2-3). This may provide an explanation for why the interaction terms were insignificant since student teaching is a short 12-16 week experience and additional teaching experience may be necessary for the reciprocal nature of the variables to occur. Furthermore, previous studies show that novice teachers often rely heavily on curricular materials and mentors early in their careers, but perceived autonomy in preservice and novice teachers increases over time as their desire for autonomy also increases (Gidalevich & Shalev, 2022; Narayanan et al., 2024). Future research could investigate this phenomenon further.

Implications

Policy Implications

Prioritize Quality Math Instruction in Field Placements

The most statistically and practically significant finding from this study is that cooperating teacher implementation of inquiry-based math instruction was the strongest predictor of student teachers' implementation among the variables examined. This underscores the importance of educator preparation programs (EPPs) to advocate for policies that will bridge the gap between coursework and field work. Teacher educators must prioritize field placements where preservice elementary teachers can regularly observe best practices in mathematics instruction (Darling-Hammond, 2006). If preservice teachers do not experience consistency between coursework and fieldwork, they may be less likely to build the confidence needed to implement inquiry-based approaches. Current policies in many EPPs require CTs to have a minimum of three years of teaching experience, however, CT instructional effectiveness is more indicative of preservice teacher effectiveness than years of experience (Rondfeldt et al., 2018). This further supports the need for a policy shift that examines CT instructional effectiveness when developing partnerships and placements.

Focus on a Shared Vision Between EPPs and Partner Districts

To pair preservice teachers with cooperating teachers who model effective mathematics teaching practices, preparation programs must develop policies that focus on a shared vision with partner schools and districts. Some programs have accomplished this goal by developing professional development schools, lab schools, and school reform networks where both university and school educators work together to set goals, develop curriculum, and engage in action research (Darling-Hammond, 2006). Teacher educators may partner with school district professional development coordinators to offer workshops promoting best practices while attending to district curriculum and policies. This vision requires a new level of collaboration between school districts and EPPs beyond districts allowing preservice teachers into classrooms and EPPs providing potential applicants for future positions. This strategic partnership may also inform how accreditation organizations assess a program’s coherence between coursework and clinical experiences.

Consider Ways to Evaluate Quality of Field Experiences

The Council for the Accreditation of Educator Preparation (CAEP) standards acknowledge the common disconnect between coursework and field experiences. The current standards require candidates to use research-supported instructional approaches and emphasize that the evaluation standards "were written with the expectation that they will be centered in clinical practice, and that coursework will be intimately tied to field experiences…" (Council for the Accreditation of Educator Preparation, 2018, p. 153). The *Clinical Partnerships and Practices* standard emphasizes field experiences with diverse student and family populations but does not assess the quality of placements or their alignment with other standards. Because this study indicates that the instructional approach of the cooperating teacher influences the instructional approach of the student teacher, accreditation programs like CAEP could consider policies that evaluate the quality of the field placement, leading EPPs to be more intentional about their clinical placements.

Examine How State and District Policies Promote or Hinder Inquiry-Based Instruction

Finally, the study can inform leaders at the district and state-levels to consider policies that may interfere with teachers' implementation of inquiry-based instruction. Curriculum selection and mandates, pacing requirements, high-stakes testing, and assessment approaches may influence whether classroom teachers, and eventually new teachers, have the confidence or autonomy to implement IBMI. Ramaila (2025) explained a need for curriculum developers and policy stakeholders to align cognitively guided instruction with national standards to address common barriers to implementation such as resource constraints and curriculum rigidity. Because both coursework and clinical experiences play a critical role in shaping future teachers, it is important that state, national, programmatic, district, and accreditation policies align to hold all stakeholders accountable for providing experiences that promote best practice in mathematics education.

Practice Implications

Intentionally Develop Inquiry-Based Math Teaching Efficacy in EPPs

Teacher educators must intentionally develop teaching efficacy specific to inquiry-based instruction throughout EPPs. Previous studies show that EPPs can change preservice teachers' attitudes, beliefs, and knowledge of math (AMTE, 2017; Benken & Brown, 2008; Chamblee et al., 2023; Fonseca, 2021; Kanadlı, 2017), and this study underscores the importance of efficacy and the implementation of inquiry-based instruction. EPPs may utilize peer observation for inquiry-based lessons since observing other preservice teachers succeed or receiving positive coaching from instructors, can raise the observer's self-efficacy (Schunk, 2012). Additionally, they can increase efficacy through self-regulation by asking preservice teachers to evaluate their inquiry-based teaching efficacy throughout the program to focus on progress (Schunk, 2012). While both personal teaching efficacy and outcome expectancy correlated with implementation of IBMI, outcome expectancy was a significant predictor of implementation when controlling for the other variables in the study. This demonstrates the importance of not only building preservice teachers' confidence in teaching using this approach, but also their understanding of why it is important and effective. This can be achieved by math teacher educators modeling inquiry-based instruction in math content and methods courses so that preservice teachers are able to experience the effects learners of mathematics and reflect on the benefits and challenges through targeted, timely discussions. Field-embedded coursework and discussions can highlight the benefits of using an inquiry-based approach by examining elementary students thinking through work samples or reflecting on their engagement when using this instructional approach.

Explicitly Prepare Student Teachers to Interpret and Navigate Misalignment

Because of the variance among cooperating teachers and their instructional approaches to teaching mathematics, it is important for teacher educators to prepare preservice teachers to recognize when misalignment occurs and provide tools for how to navigate these situations. Acknowledging barriers to change in math education can provide real world perspective and allow preservice teachers to approach their field experiences with an open mind while also reflecting deeply about how to improve their own instruction. Asking preservice teachers to reflect on common challenges that they have encountered in field placements, whether it be mandated curriculum, colleagues with differing views of how to teach mathematics, or limited resources for manipulatives, and then brainstorming ways to respond if they find themselves in those challenges can build their agency and collaboration skills when as they enter the field as early professionals.

Prioritize Ongoing Support for In-Service Teachers in Inquiry-Based Math Instruction

Additionally, this finding presents an opportunity for districts and administrators to consider professional development opportunities for in-service teachers. Professional development should include ongoing support from math teacher educators or experts in the field who can model the approach for in-service teachers and provide implementation feedback. Additionally, districts can invest in tailored, long-term professional development around cognitively guided instruction, promote collaborative teacher networks, and leverage technology in settings with limited physical resources (Ramaila, 2025). If school districts aim to hire new teachers equipped with the confidence and skills needed to teach effectively, they must invest in their current teachers to provide models to novice teachers entering the profession. New teachers entering the field are more likely to implement IBMI if they have an opportunity to observe the approach being modeled successfully by a more experienced teacher. Additionally, observations and feedback provided by administrators to in-service teachers must align with best practices in mathematics education to promote inquiry-based instructional practices.

Theoretical Implications

The results of the study contribute to the existing body of literature drawing on social cognitive theory. While Bandura (2014) notes that sources of influence can differ in strength, this becomes apparent in the current study where only two of the four factors emerged as significant predictors of student teachers' implementation of IBMI. This seems to indicate that, within SCT, the strength of certain factors may differ given situational contexts or environments. Cooperating teacher's implementation of IBMI, a vicarious experience through the SCT framework, and outcome expectancy as a personal determinant outweighed personal efficacy and instructional autonomy in the student teaching context. Research on SCT could extend to examine how the strength of different variables within the framework emerges within different contexts.

While instructional autonomy was not a significant predictor in this study, a previous one noted that sometimes novice teachers are initially unsure of how much flexibility is allowed when it comes to teaching materials or curriculum, but that perceived autonomy can increase over time (Narayanan et al., 2024). Additionally, preservice teachers' desire for autonomy can also increase over time (Gidalevich & Shalev, 2022). In the context of SCT, it is possible that instructional autonomy could emerge as a significant predictor of IBMI later in a teacher's career, but the highly structured environment of student teaching simply does not allow it since "cooperating teachers have a powerful influence on the nature of the student teaching experience" (Wilson et al., 2002, p.195). This could also explain why the student teachers' efficacy, or their belief in their ability to implement IBMI, was not significant while their outcome expectancy, or belief that the method is effective, was significant. It is possible that at this early stage of their career their belief that the method is effective outweighs their confidence in teaching, something that could shift over their teaching career. Therefore, SCT may be refined to consider career stages of teachers and how environmental, personal, and behavioral factors might influence future behavior at different points in time.

Finally, the lack of significance among the interaction terms in the moderation analysis could point to Bandura's (2014) explanation that reciprocal influences do not occur simultaneously and that it often takes time to activate reciprocal influences. If these influences exist in a teaching context, how much time must pass for the relationships to emerge? What factors may hinder or expedite this reciprocal process? This study provides an opportunity to examine this aspect of SCT more in-depth in future research designs.

Methodological Implications

The survey development and quantitative methods utilized in the study also offer implications. Numerous studies focus on teacher efficacy as an important personal factor in teaching across a variety of content areas and contexts given that it is an integral component of Social Cognitive Theory. This study moved beyond looking at efficacy in isolation and included environmental factors to fully examine variables representing all parts (personal, environmental, behavioral) of the SCT framework, something uncommon in teacher education. Including variables beyond efficacy also provided an opportunity to examine the importance of efficacy in relation to other factors so as not to over or under state the role of efficacy. Additionally, efficacy was examined separately as personal efficacy and outcome expectancy, offering deeper understanding of the construct.

Rather than simply collecting descriptive data, the study aimed to identify which variables carried more weight when considered together rather than individually. By using multiple regression analysis, the findings provide teacher educators with specific factors to develop when promoting IBMI. The variables used in the regression analysis also extended beyond demographic factors commonly used in regression such as age and ethnicity. The study intentionally utilized moderation regression to test reciprocal determinism described in SCT. While none of the interaction effects were significant, the methodology could be repeated with a larger or more varied sample to continue investigating this approach in combination with SCT ideas.

The scales that were developed as part of this study provide opportunities for others to build on this research. While a general teaching efficacy scale is published and widely used in math education research, this study provides an alternative for research that focuses specifically on efficacy related to inquiry-based mathematics teaching. Future use of this instrument could provide teacher educators with a better understanding of teaching efficacy related to different instructional approaches, allowing for more targeted development in preservice teachers.

While instructional autonomy in preservice teachers was not a predictor of their implementation of IBMI, the newly developed scale can offer implications for future researchers who aim to explore instructional autonomy in preservice teachers. The items are written in such a way that they could be revised to address instructional autonomy outside of the mathematics context.

Boundaries of the Study

Limitations

Several limitations should be acknowledged in this study. First, common method bias (Podsakoff et al., 2003) should be noted as a potential limitation given that the predictor and criterion variables are both reported by the same person, in this case, the student teacher at a single point in time. This can lead to inflated correlations among the variables. This possibility exists in the finding noting the cooperating teacher's implementation as the strongest predictor of student teacher's implementation since both behaviors are reported by the student teacher at one moment in time. It is possible that observations of instructional methods could provide a different result than the student teacher's perception. Consistency motif could be present as the participants may attempt to show consistency in their implementation of inquiry-based math instruction and outcome expectancy, another relationship that was found to be significant in the multiple regression model. Additionally, common method bias notes that transient mood states can influence responses to a questionnaire when participants are asked to report on behaviors and beliefs at single moment in time. This could lead to varying responses given the mood and stress level of the student teacher on the day they completed the survey. Future research could strengthen internal validity and address the limitation of common methods bias by incorporating multiple data sources such as classroom observations of instructional practices, reporting from the cooperating teacher, and longitudinal studies that examine changes across time.

While all participating educator preparation programs (EPPs) were accredited by their respective states, specific information about the mathematics frameworks promoted at each EPP was not available. Although AMTE (2017) recommends that educator preparation programs draw on research-based frameworks, the study did not assess whether, or to what extent, the programs promoted or modeled best practices in mathematics instruction. The same limitation applies to the school districts where participants completed their student teaching. Different districts vary in the curriculum resources they use, the quality of math professional development they provide, and the overall culture they promote---none of which was quantified or controlled for in this study. Additionally, the study did not control for the participants prior exposure to IBMI in coursework or field experiences prior to student teaching.

The subscales used to measure inquiry-based math instruction (IBMI)---both for student teachers and cooperating teachers---consisted of only four items. While the items reflect core components of IBMI, they may not fully capture the complexity of this instructional approach. Expanding and piloting additional items in future research could increase scale reliability and validity. It may also be worthwhile to consider scale descriptions outside of *no lessons, some lessons, most lessons, all lessons* to quantify the number of times the student teacher implements the approach. For example, a student teacher who taught ten total lessons and used IBMI for eight of those may select *most lessons*, yet a student teacher who taught fifty total lessons and also used IBMI for eight of those may select *some lessons.* This may have led to discrepancies among the values being reported for this variable.

Additionally, the STIBMI relied on student teachers to self-report on their implementation of IBMI which introduces potential bias since preservice teachers can sometimes report feeling more confident than their actual skills reveal (Austin, 2015). The student teachers also reported on the instructional practices used by their cooperating teacher. It is unclear if, as novice teachers, the participants were able to accurately identify the practices while observing their cooperating teacher, and it is possible that the cooperating teachers may be using inquiry-based methods without the student teacher noticing. While this limitation was considered during the study design, future research should consider triangulating self-reports with lesson observations of both the student teacher and cooperating teacher to assess the accuracy of the scale.

The IBMTOE subscale measured student teachers' beliefs about the effectiveness of IBMI for student learning but did not include other types of outcome expectancies. According to Social Cognitive Theory (Bandura, 2000), individuals weigh both rewarding and unrewarding outcomes when deciding whether to engage in a specific behavior. Including items that address potential negative outcomes (e.g., falling behind in curriculum pacing, resistance from administrators) and reverse-coded items could capture a broader range of beliefs and reduce response bias.

Drawing on existing literature, the cooperating teacher's influence was chosen as the focus of this study. However, other human influences such as university supervisors, principals, mathematics coaches, or peers likely influence student teachers' behavior none of which were accounted for in the current study.

Finally, the study is limited to midwestern universities with most participants being females between the ages of 18-23 years old. Participation was also voluntary, which may have introduced self-selection bias. While the sample size (N = 130) met statistical requirements for the analyses, a larger and more diverse sample could increase generalizability and provide greater power to detect smaller effect sizes.

Recommendations for Future Research

How do the contextual factors related to both the student teacher and cooperating teacher influence how mathematics is approached in elementary classrooms?

The findings from this study offer several directions for future research. Because this study relied only on the student teachers' self-reporting to measure each of the variables in the study, it is important to build on these findings using qualitative methods such as narrative or case study approaches. Classroom observations of both the student teachers and cooperating teachers would allow for more accurate reporting of the instructional methods being used in the elementary classrooms. Rich biographies of student teachers would offer more insight into important contextual data such as the number of hours student teachers completed in field placements during their program, their experiences in their math methods and content courses, and their previous experiences with teaching math lessons prior to student teaching. Cooperating teacher biographies might include teaching experience, teaching and mentoring philosophies, curriculum expectations, and professional development experiences. Including qualitative components would allow researchers to gain a more holistic understanding of the complexities involved in instructional decision making and how those influence mathematics instruction.

How do cooperating teachers perceive their teaching efficacy related to inquiry-based mathematics instruction?

Because cooperating teacher implementation was the strongest predictor of student teachers' implementation of IBMI, it is worth examining the math teaching efficacy of cooperating teachers specific to inquiry-based practices. More experienced teachers may have developed efficacy with traditional teaching methods, and their confidence and outcome expectancy for IBMI could differ. Classroom observations could examine how their self-reported efficacy compares to their instructional practice, and this would provide two separate measures rather than asking the cooperating teacher to report on both their efficacy and implementation. Understanding these distinctions could inform how cooperating teachers are selected and supported, ensuring that student teachers are placed in classrooms where high-quality math instruction is modeled.

What variables outside of those examined in this study influence cooperating teachers' math instructional decision making?

Furthermore, it seems logical to investigate additional factors outside of efficacy that hinder or promote inquiry-based practices in cooperating teachers. Future research might explore how instructional autonomy hinders or encourages innovative teaching in cooperating teachers. Additional variables, such as curriculum requirements, pressure from administrators, or district policies, could be examined to determine other external factors that influence instructional autonomy and decision-making in cooperating teachers.

How do student teachers perceive the importance of instructional autonomy and how does it influence their overall teaching experience?

Although student teachers perceived instructional autonomy was not a significant predictor in this study, it would be worthwhile to examine how instructional autonomy contributes to preservice teachers' overall experience during student teaching. It is possible that those who perceive autonomy during student teaching will build stronger, more trusting relationships with their cooperating teachers, while others may feel overwhelmed if the autonomy is not balanced with structured support. Examining the balance between autonomy and support could help teacher educators, cooperating teachers, and university supervisors understand how student teachers navigate this important passage from preservice teacher to early professional. Teacher preparation programs may investigate ways to build qualities in preservice teachers that allow them to utilize autonomy in an effective way. The lack of literature surrounding instructional autonomy specific to preservice teachers indicates more exploration in this area.

What experiences or activities are most impactful for increasing inquiry-based math teaching efficacy in preservice teachers?

Future research should also explore specific approaches within EPPs that are most effective at developing preservice teachers' efficacy for inquiry-based math instruction. Identifying high-leverage practices that contribute to the development of strong teaching efficacy can ensure that student teachers are better prepared to implement IBMI. Since outcome expectancy was a significant predictor of IBMI in the current study, it would be especially beneficial to identify experiences strongly influence the belief that IBMI leads to student success.

When the cooperating teacher, the strongest influence in the current study, is removed, what determines how teachers pursuing provisional certification approach mathematics instruction?

Finally, many districts across the United States are currently facing a teacher shortage and student teachers are frequently being hired to fill these vacant positions as they pursue provisional certification pathways. In these situations, they do not student teach in a traditional setting where they have the coaching and mentoring of a certified cooperating teacher. Future research might explore what factors influence the instructional decision making of these provisional teachers when they do not have the influence of a cooperating teacher.

Conclusion

This study was prompted by the researcher's experiences as a teacher educator observing a disconnect between coursework and fieldwork among elementary preservice teachers, a concern that is also supported by current research. The study was initially designed to examine four variables that previous literature identified as being important to elementary student teachers' implementation of inquiry-based mathematics instruction. The goal was to explore the relationships to determine which factors were important for EPPs and partner school districts to consider for developing effective elementary math teachers.

The results of the study align with previous research and Bandura's (1989) social cognitive theory indicating that implementation of inquiry-based instruction consists of the relationship between personal, behavior, and environmental factors. The strongest predictor of elementary student teachers' implementation of inquiry-based instruction was cooperating teacher implementation of the approach, with inquiry-based outcome expectancy also emerging as a significant predictor in the regression model. Personal teaching efficacy and perceived instructional autonomy were not significant in the model, indicating that having the confidence and freedom to teach using IBMI is not enough for student teachers to implement this instructional approach. In addition, they must see the approach being effectively modeled by experienced teachers, and they must believe that it will lead to effective outcomes.

The findings of this study reinforce the important role of the cooperating teacher as both an instructional model and gatekeeper of effective math instruction. Because student teachers rely on observational learning and vicarious experiences (Bandura, 2014) when navigating unfamiliar instructional approaches, pedagogical practices modeled by cooperating teachers appear to shape whether student teachers view IBMI as valued and expected in real elementary classrooms. By identifying these factors, educator preparation programs and school district leaders can consider strategies for building efficacy in both preservice and in-service teachers. In-service teachers must develop efficacy and the ability to successfully implement inquiry-based instruction if we want student teachers to be more likely to use this approach as they transition from teacher training to classroom teacher.

Although perceived instructional autonomy did not show a strong relationship with the implementation of inquiry-based instruction, it remains relevant in teacher education and provides opportunities for future evaluation and exploration. Perceived autonomy specific to student teachers has not been extensively researched, and future studies can contribute to the theoretical and practical understanding of autonomy and its place in teacher development in math education.

In addition to these findings, five new subscales have emerged from the study to be refined, tested, and used in future research. Hopefully, the new scales, four of which focus specifically on inquiry-based math instruction, will be helpful for contributing more knowledge to the field of mathematics education and for promoting this instructional approach.

Teaching is a complex endeavor with endless factors that influence each individual teacher and their instructional decisions. Like so many other professions, new teachers learn from their more experienced counterparts. Educator preparation programs can work to develop efficacy and help preservice teachers recognize the positive outcomes of inquiry-based math instruction, but cooperating teachers must also successfully model the approach and provide feedback to novice teachers for real change to occur. Although the gap between theory and practice continues to challenge math education, this study contributes to the ongoing effort to bridge the gap by highlighting factors that support inquiry-based mathematics instruction.

References

Akkus, M. (2015). The common core state standards for mathematics. *International Journal of Research in Education and Science, 2*(1), 49. https://doi.org/10.21890/ijres.61754

Alshehri, K. A., & Youssef, N. H. (2022). The Influence of Mathematical Knowledge for Teaching towards Elementary Teachers' Mathematical Self-Efficacy. *EURASIA Journal of Mathematics, Science and Technology Education*, *18*(6).

Althauser, K. L. (2018). The Emphasis of Inquiry Instructional Strategies: Impact on Preservice Teachers' Mathematics Efficacy. *Journal of Education and learning*, *7*(1), 53-70.

Anderson, D. (2009). The impact of cooperating teachers on the teaching perspectives of student teachers. The International Journal of Learning: Annual Review, 16(1), 119–134. https://doi.org/10.18848/1447-9494/CGP/v16i01/45883

Artino Jr, A. R., La Rochelle, J. S., Dezee, K. J., & Gehlbach, H. (2014). Developing questionnaires for educational research: AMEE Guide No. 87. *Medical teacher*, *36*(6), 463-474.

Association of Mathematics Teacher Educators. (2017). *Standards for preparing teachers of mathematics.* Association of Mathematics Teacher Educators. https://amte.net/standards

Austin, J. (2015). Prospective teachers' personal Mathematics teacher efficacy beliefs and Mathematical knowledge for teaching. *International Electronic Journal of Mathematics Education*, *10*(1), 17-36.

Ball, D. (1990). The Mathematical Understandings That Prospective Teachers Bring to Teacher Education; *The Elementary School Journal, 90*(4), 449-446.

Bandura, A. (1989). Social cognitive theory. In R. Vasta (Ed.), Annals of child development. Vol. 6. Six theories of child development (pp. 1-60). Greenwich, CT: JAI Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control* (Vol. 11). Freeman.

Bandura, A. (2000). Social cognitive theory: An agentic perspective. *Asian journal of social psychology*, *2*(1), 21-41.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In Urdan, T., & Pajares, F. (eds.), *Self-efficacy beliefs of adolescents.* (pp. 307-337). Information Age Publishing.

Bandura, A. (2012). On the functional properties of perceived self-efficacy revisited. *Journal of management*, *38*(1), 9-44.

Bandura, A. (2014). Social-cognitive theory. In An introduction to theories of personality (pp. 341-360). Psychology Press.

Bates, A. B., Latham, N., & Kim, J. A. (2011). Linking preservice teachers' mathematics Self-Efficacy and mathematics teaching efficacy to their mathematical performance. *School Science and Mathematics*, *111*(7), 325-333.

Benkin, B. & Brown, N. (2008). Integrating teacher candidates' conceptions of mathematics, teaching, and learning: A cross-university collaboration. *Issues in the Undergraduate Mathematics Preparation of School Teachers IUMPST: The Journal. 1.* 1-15.

Boaler, J. (2015). *Fluency without fear: Research evidence on the best ways to learn math facts.* YouCubed.

Boaler, J. (2016). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching.* Jossey-Bass/Wiley.

Boyacı, Z., & Erdamar, G. (2023). Lesson Study's Effect on Math Teacher Candidates' Attitudes, Self-Efficacy, and Teaching Anxiety. *Asian Journal of Instruction (E-AJI)*, *11*(2), 23-42.

Boyd, D. J., Grossman, P. L., Lankford, H., Loeb, S., & Wyckoff, J. (2009). Teacher preparation and student achievement. *Educational Evaluation and Policy Analysis, 31*(4), 416–440.

Brownell, W. A. (1934). Psychological considerations in the learning and teaching of arithmetic. In National Council of Teachers of Mathematics (Ed.), *The teaching of arithmetic* (10th Yearbook). New York: Bureau of Publications, Teachers College, Columbia University, 1935), pp. 1-31.

Burstein, L., McDonnell, L. M., Winkle, J. V., Ormseth, T., & Guitton, G. (1995). *Validating National Curriculum Indicators*.

Byrd, K. O., & Giles, R. M. (2023). Preservice Teachers' Self-Efficacy for Teaching Mathematics. *SRATE Journal*, *32*(1), n1.

Carney, M. B., Brendefur, J. L., Hughes, G. R., & Thiede, K. (2015). Developing a mathematics instructional practice survey: Considerations and evidence. *Mathematics Teacher Educator*, *4*(1), 93-118.

Carpenter, T. P., & Fennema, E. (1992). Cognitively guided instruction: Building on the knowledge of students and teachers. *International Journal of Educational Research*, *17*(5), 457-470.

Carpenter, T. P., Fennema, E., & Franke, M. L. (1996). Cognitively guided instruction: A knowledge base for reform in primary mathematics instruction. *The elementary school journal*, *97*(1), 3-20.

Cassel, D., & Vincent, D. (2011). Metaphors reveal preservice elementary teachers' views of mathematics and science teaching. *School Science and Mathematics, 111*(7), 319–324. https://doi.org/10.1111/j.1949-8594.2011.00094.x

Chamberlin, M. T. (2013). Prospective teachers' perspectives on mathematics teaching and learning: Lens for interpreting experiences in a standards-based mathematics course. *School Science and Mathematics, 113*(8), 369–379. https://doi.org/10.1111/ssm.12042

Chamblee, G., An, T., Nguyen, H., Maher, E. M., Eisenreich, H., & Rogerson, D. (2023). K-8 Preservice Teachers' Numeracy (Number Sense) Knowledge. In *Proceedings of the Annual Meeting of the Georgia Association of Mathematics Teacher Educators*, *14*(1). 51-67.

Chang, Y.L. (2015). Examining relationships among elementary mathematics teacher efficacy and their students' mathematics self-efficacy and achievement. *Eurasia Journal of Mathematics, Science and Technology Education, 11*(6), 1307–1320. https://doi.org/10.12973/eurasia.2015.1387a

Check, J., & Schutt, R. (2012). Survey research. In Survey research (Vol. 0, pp. 159-186). SAGE Publications, Inc., https://doi.org/10.4135/9781544307725.n8

Chyung, S. Y., Swanson, I., Roberts, K., & Hankinson, A. (2018). Evidence-based survey design: The use of continuous rating scales in surveys. *Performance Improvement*, *57*(5), 38-48.

Clark, L. A., & Watson, D. (1995). Constructing validity: Basic issues in objective scale development. Psychological assessment, 7(3), 309.

Connor, K., & Killmer, N. (1995). *Evaluation of cooperating teacher effectiveness*. Paper presented at the Midwest Educational Research Association Annual Meeting, Chicago, IL.

Council for the Accreditation of Educator Preparation. (2018). *2018 CAEP K-6 elementary teacher preparation standards*. https://caepnet.org/~/media/Files/caep/standards/2018-caep-k-6-elementary-teacher-prepara.pdf?la=en

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Sage Publications.

Crosswhite, F. J., Dossey, J. A., & Frye, S. M. (1989). NCTM standards for school mathematics: Visions for implementation. *Journal for Research in Mathematics Education, 20*(5), 513–522. https://doi.org/10.2307/749425

Darling-Hammond, L. (2006). Constructing 21st-century teacher education. *Journal of teacher education*, *57*(3), 300-314.

DeCastellarnau, A. (2018). A classification of response scale characteristics that affect data quality: a literature review. *Quality & quantity*, *52*(4), 1523-1559.

Delgado, L. (2019). An exploration of the development of student-teacher autonomy and the role of professional identity and mentoring: A case study of ESOL trainees in a northern university in Mexico (Doctoral dissertation, University of Southampton).

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). Internet, phone, mail, and mixed-mode surveys: The tailored design method. *Indianapolis, Indiana*.

Enochs, L. G., & Riggs, I. M. (1990). Further development of an elementary science teaching efficacy belief instrument: A preservice elementary scale.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and mathematics*, *100*(4), 194-202.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103*(6). 1013-1055.

Ferguson, L. E., & Bråten, I. (2022). Unpacking preservice teachers' beliefs and reasoning about student ability, sources of teaching knowledge, and teacher-efficacy: A scenario-based approach. *Frontiers in Education, 7*. 1-16.

Fernandez, M. L., & Erbilgin, E. (2009). Examining the supervision of mathematics student teachers through analysis of conference communications. *Educational Studies in Mathematics, 72*(1), 93–110. https://doi.org/10.1007/s10649-009-9185-1

Field, A. P. (2018). Discovering statistics using IBM SPSS statistics (5th ed.). SAGE Publications Ltd.

Fink, A. (2006). How to conduct surveys: A step-by-step guide (3rd ed.). SAGE Publications.

Fonseca, K. (2021). Self-reported mathematical problem-solving skills of future mathematics teachers. *South African Journal of Childhood Education, 11*(1). https://doi.org/10.4102/sajce.v11i1.1011

Fowler, F. J. (2009). Survey research methods (4th ed.). SAGE Publications, Inc., https://doi.org/10.4135/9781452230184

Friedman, I. A. (1999). Teacher-perceived work autonomy: The concept and its measurement. *Educational and psychological Measurement*, *59*(1), 58-76.

Frykholm, J. A. (1996). Preservice teachers in mathematics: Struggling with the standards. *Teaching and Teacher Education, 12*(6), 665–681. https://doi.org/10.1016/S0742-051X(96)00010-8

Gidalevich, S., & Shalev, M. (2022). Changing needs of special education preservice teachers in the practicum. *Australian Journal of Teacher Education (Online)*, *47*(4), 21-38.

Gholam, A. P. (2019). Inquiry-based learning: Student teachers' challenges and perceptions. *Journal of Inquiry and Action in Education*, *10*(2), 6.

Haciomeroglu, G. (2013). The field experiences of student teachers and effective mathematics teaching in turkey. *Australian Journal of Teacher Education, 38*(2). https://doi.org/10.14221/ajte.2013v38n2.5

Haimovitz, K., & Dweck, C. S. (2017). The origins of children's growth and fixed mindsets: New research and a new proposal. *Child development*, *88*(6), 1849-1859.

Harper, N. W., & Daane, C. J. (1998). Causes and reduction of math anxiety in preservice elementary teachers. *Action in Teacher Education, 19*(4), 29–38. https://doi.org/10.1080/01626620.1998.10462889

Hood, Christine E. *Elementary Preservice Math Teachers' Evolving Dispositions Throughout a Math Methods Course: A Mixed Methods Study*. Diss. University of Denver, 2023.

Jansen, A., Berk, D., & Meikle, E. (2017). Investigating alignment between elementary mathematics teacher education and graduates' teaching of mathematics for conceptual understanding. Harvard Educational Review, 87(2), 225-250.

Jeffery, T. D., Hobson, L. D., Conoyer, S. J., Miller, K. E., & Leach, L. F. (2018). Examining ec-6 preservice teachers' perceptions of self-efficacy in teaching mathematics. *Issues in the Undergraduate Mathematics Preparation of School Teachers: The Journal, Vol. 5 (Teacher Attributes)*, *5*.

Johnson, P., Shuilleabhain, A., Riordain, M., & Prendergast, M. (2019). The evolution of student teachers' concerns regarding mathematics curricular reform. *International Journal of Science and Mathematics Education, 18*. 1293-1310.

Kaiser, H. F. (1974). An index of factorial simplicity. psychometrika, 39(1), 31-36.

Kanadlı, S. (2017). Prospective teachers' professional self-efficacy beliefs in terms of their perceived autonomy support and attitudes towards the teaching profession: A mixed methods study. *Kuram Ve Uygulamada Egitim Bilimleri*, *17*(5), 1847-1871.

Kang, H. (2016). The Role of Mentor-Student Teacher Relationships in Building Standard-Based Elementary Mathematics Teaching Pedagogy. *Journal of Educational Research and Innovation*, *5*(2), 3.

Kang, H. J. (2022). Preservice Elementary Teachers Understanding of Fraction Multiplication and Division in Multiple Contexts. *International Electronic Journal of Elementary Education, 2*. https://doi.org/10.26822/iejee.2023.283

Kim, D., Twombly, S., & Wolf-Wendel, L. (2008). Factors predicting community college faculty satisfaction with instructional autonomy. *Community College Review*, *35*(3), 159-180.

Koutsianou, A., & Emvalotis, A. (2019). Greek pre-service primary teachers' efficacy beliefs in science and mathematics teaching: Initial adaptation of the STEBI-B and MTEBI instruments. *International Journal of Educational Methodology*, *5*(3), 375-385.

Lamm, K. W., Lamm, A. J., & Edgar, D. (2020). Scale development and validation: Methodology and recommendations. Journal of International Agricultural and Extension Education, 27(2), 24-35.

Li, K., Wijaya, T.T., Chen, X., & Harahap, M.S. (2024). Exploring the factors affecting elementary mathematics teachers' innovative behavior: an integration of social cognitive theory. *Scientific Reports, 14*(2108). https://doi.org/10.1038/s41598-024-52604-4

Loewenberg Ball, D., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*(5), 389–407. https://doi.org/10.1177/0022487108324554

Looney, L., Perry, D., & Steck, A. (2017). Turning negatives into positives: The role of an instructional math course on preservice teachers' math beliefs. *Education, 138*(1), 27–40.

Lortie, D. C. (1975). *Schoolteacher: A sociological study*. University of Chicago press.

McMinn, M., Aldridge, J., & Henderson, D. (2021). Learning environment, self-efficacy for teaching mathematics, and beliefs about mathematics. *Learning Environments Research*, *24*(3), 355-369.

Miler, J. M., Youngs, P., Anagnostopoulos, D., & Drake, C. (2023). How cooperating teachers and university supervisors shape elementary candidates' opportunities to learn and receive feedback on English Language Arts instruction. *Teacher Education Quarterly, 50*(2), 6–28.

Mokoena, T. D., & van Tonder, G. P. (2024). Influencing beginner teachers' autonomy: the impact of mentorship in fostering self-directed learning. International Journal of Educational Management, 38(5), 1265-1288.

Narayanan, M., Shields, A. L., & Delhagen, T. J. (2024). Autonomy in the spaces: Teacher autonomy, scripted lessons, and the changing role of teachers. Journal of Curriculum Studies, 56(1), 17-34.

National Center for Education Statistics. (2023, December 19). Characteristics of Public School Teachers. https://nces.ed.gov/programs/coe/indicator/clr/public-school-teachers

National Council of Teachers of Mathematics. (n.d.). *Teaching and learning beliefs survey*. Retrieved from https://www.nctm.org/uploadedFiles/Publications/teaching_children_mathematics/TCM_Blog/2017_06_19_Holstrom_Grady_2BeliefsSurvey.pdf

National Council of Teachers of Mathematics. Commission on Standards for School Mathematics. (1989). Curriculum and evaluation standards for school mathematics. National Council of Teachers of Mathematics.

National Council of Teachers of Mathematics. (2000). Principles and standards for school mathematics; Reston, VA: NCTM.

National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all.* NCTM.

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards for Mathematics*. http://www.corestandards.org

National Research Council. (2010). *Preparing teachers: Building evidence for sound policy.* Committee on the Study of Teacher Preparation Programs in the United States, Center for Education. Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

The Nation's Report Card. (2023, December 20). Results from the 2019 Mathematics and Reading Assessments at Grade 12. https://www.nationsreportcard.gov/highlights/mathematics/2019/g12/

Newton, K. J., Leonard, J., Evans, B. R., & Eastburn, J. A. (2012). Preservice elementary teachers' mathematics content knowledge and teacher efficacy: Content knowledge and teacher efficacy. *School Science and Mathematics, 112*(5), 289–299. https://doi.org/10.1111/j.1949-8594.2012.00145.x

Nihayah, R. W., Dina, W. F., Wijayanti, D., & Asyah, A. N. (2023). How does granting teacher autonomy influence classroom instruction? Lessons from Indonesia's curriculum reform implementation. *Jurnal Penelitian Kebijakan Pendidikan*, *16*(1).

Perry, C. J. (2023). Elementary preservice mathematics teachers' fraction knowledge: An integrative review of research. *Educational Considerations, 49*(1). https://doi.org/10.4148/0146-9282.2346

Peterson, B., & Williams, S. (2008). Learning mathematics for teaching in the student teaching experience: Two contrasting cases. *Journal of Mathematics Teacher Education, 11*(6), 459–478. https://doi.org/10.1007/s10857-008-9085-9

Pett, M. A., Lackey, N. R., & Sullivan, J. J. (2003). Making sense of factor analysis: The use of factor analysis for instrument development in health care research. SAGE Publications.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., & Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. Journal of applied psychology, 88(5), 879.

Ramaila, S. (2025). Cognitively guided instruction in education: a review of research trends and classroom applications. Cogent Education, 12(1), 2550619.

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development, 14*(2), 187–202. https://doi.org/10.1080/15248372.2012.664593

Ravid, R. (2020). *Practical statistics for educators* (6th ed.). Rowman & Littlefield.

Rea, L. M., & Parker, R. A. (2014). *Designing and conducting survey research: A comprehensive guide* (4th ed.). Wiley.

Richardson, G. M., & Liang, L. L. (2008). The use of inquiry in the development of preservice teacher efficacy in mathematics and science. *Journal of Elementary Science Education*, *20*(1), 1-16.

Ronfeldt, M., & Grossman, P. (2008). Becoming a professional: Experimenting with possible selves in professional preparation. *Teacher Education Quarterly, 35*(3), 41–60.

Ronfeldt, M., Reininger, M., & Kwok, A. (2013). Recruitment or preparation? Investigating the effects of teacher characteristics and student teaching. Journal of Teacher Education, 64(4), 319-337.

Ronfeldt, M., Brockman, S. L., & Campbell, S. L. (2018). Does cooperating teachers' instructional effectiveness improve preservice teachers' future performance?. *Educational Researcher*, *47*(7), 405-418.

Ross, J. A., McDougall, D., Hogaboam-Gray, A., & LeSage, A. (2003). A Survey Measuring Elementary Teachers' Implementation of Standards-Based Mathematics Teaching. *Journal for Research in Mathematics Education*, *34*(4), 344–363. https://doi.org/10.2307/30034787

Saligumba, I. P., & Tan, D. A. (2018). Gradual release of responsibility instructional model: Its effects on students' mathematics performance and self-efficacy. *International Journal of Scientific & Technology Research*, *7*(8), 276-291.

Sayeski, K. L., & Paulsen, K. J. (2012). Student teacher evaluations of cooperating teachers as indices of effective mentoring. *Teacher Education Quarterly*, *39*(2), 117-130.

Schunk, D. H. (2012). Social cognitive theory.

Seely, K. (2014). *Smarter than we think.* Math Solutions.

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

Simmons, P. E., Emory, A., Carter, T., Coker, T., Finnegan, B., Crockett, D., Richardson, L., Yager, R., Craven, J., Tillotson, J., Brunkhorst, H., Twiest, M., Hossain, K., Gallagher, J., Duggan-Haas, D., Parker, J., Cajas, F., Alshannag, Q., McGlamery, S., … Labuda, K. (1999). Beginning teachers: Beliefs and classroom actions. *Journal of Research in Science Teaching, 36*(8), 930–954. https://doi.org/10.1002/(SICI)1098-2736(199910)36:8<930::AID-TEA3>3.0.CO;2-N

Siwatu, K. O. (2007). Preservice teachers' culturally responsive teaching self-efficacy and outcome expectancy beliefs. *Teaching and teacher education*, *23*(7), 1086-1101.

Slocum, W. (1971). *The American calculator (1831).* In J. K. Bidwell & R. G. Clason (Eds.), *Readings in the history of mathematics education* (pp. 3-12). National Council of Teachers of Mathematics.

Smith, J. (1996). Efficacy and teaching mathematics by telling: A challenge for reform. *Journal for Research in Mathematics Education, 27* (4), 387-402.

Streiner, D. L. (2003). Starting at the beginning: an introduction to coefficient alpha and internal consistency. Journal of personality assessment, 80(1), 99-103.

Sun, D., & Zhang, Q. (2024). Evolution of Teachers' Teaching Beliefs About Mathematics in a Teacher Education Program. *Behavioral Sciences*, *14*(10), 934.

Swars, S. L., Daane, C. J., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics, 106*(7), 306–315. https://doi.org/10.1111/j.1949-8594.2006.tb17921.x

Takunyaci, M. (2021). Investigation of mathematics teachers' self-efficacy in teaching mathematics in the COVID-19 pandemic process. Education Quarterly Reviews, 4(2).

Thorndike, E. (1921). The Psychology of Drill in Arithmetic: The Amount of Practice. *The Journal of Educational Psychology, 12(4),* 183-194.

Ulas, J., & Aksu, M. (2015). Development of teacher autonomy scale for Turkish teachers. *Procedia-Social and Behavioral Sciences*, *186*, 344-349.

Van de Walle, J. A., Karp, K. S., Bay-Williams, J. M., Wray, J. A., & Brown, E. T. (2019). *Elementary and middle school mathematics: Teaching developmentally* (10th ed.). Pearson.

Vijayaprabha, G., Vasuki, M., & Kumar, A. D. (2015). Innovations in Teaching: A Review of Contemporary Methods in Mathematical Education. *Journal of Engineering Scientific Research and Applications*, *1*(2), 95-111.

Walcott, D. G., & Lambdin, D. V. (2007). Connections between psychological learning theories and the school mathematics curriculum. *Journal of Mathematics Education at Teachers College*, *1*(1), 1–8.

Wang, J., & Odell, S. J. (2007). An alternative conception of mentor–novice relationships: Learning to teach in reform-minded ways as a context. *Teaching and Teacher Education, 23*(4), 473–489. https://doi.org/10.1016/j.tate.2006.12.010

Weasmer, J., & Woods, A. M. (2003). The role of the host teacher in the student teaching experience. *The Clearing House, 76*(4), 174–177.

Whitney, L., Golez, F., Nagel, G., Nieto, C., & Nieto, C. (2002). Listening to voices of practicing teachers to examine the effectiveness of a teacher education program. *Action in Teacher Education, 23*(4), 69–76. https://doi.org/10.1080/01626620.2002.10463090

Wilson, S. M., Floden, R. E., & Ferrini-Mundy, J. (2002). Teacher preparation research: An insider's view from the outside. *Journal of teacher education*, *53*(3), 190-204.

Yee, A. H. (1969). Do cooperating teachers influence the attitudes of student teachers? *Journal of Educational Psychology, 60*(4, Pt.1), 327–332. https://doi.org/10.1037/h0027843

Yockey, R. D. (2023). SPSS demystified: A simple guide and reference (4th ed.). Routledge.

Yong, A. G., & Pearce, S. (2013). A beginner's guide to factor analysis: Focusing on exploratory factor analysis. *Tutorials in quantitative methods for psychology*, *9*(2), 79-94.

Zeichner, K. M. (1980). Key processes in the socialization of student teachers: Limitations and consequences of oversocialized conceptions of teacher socialization. *Annual Meeting of American Educational Research Association.*

Appendix A - Survey Scales: Initial and Refined Versions

A1: Student Teacher Inquiry-Based Mathematics Instruction Initial Scale (STIBMI)

Item #	Item Text	Included in Refined Scale?
STIBMI-1	How often did you begin lessons with a real-world problem for students to explore using their own strategies before you demonstrated a solution?	No
*STIBMI-2	How often did you begin lessons by demonstrating a procedure before having students solve similar problems using the same procedure?	No
STIBMI-3	How often did students use concrete or virtual manipulatives to explore problems before you provided direct instruction?	Yes
STIBMI-4	How often did you ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	Yes
*STIBMI-5	How often did you immediately demonstrate the solution when students were frustrated or confused?	No
STIBMI-6	How often did you ask students to explain their mathematical reasoning beyond sharing the steps they followed to arrive at an answer?	No
*STIBMI-7	How often did your lessons emphasize procedural steps for getting the correct answer rather than conceptual understanding?	No
STIBMI-8	How often did you assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	Yes
STIBMI-9	How often did you use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	Yes

*indicates recoding prior to analysis

A2: STIBMI Refined Scale (4 items retained)

Item #	Item Text
STIBMI-3	How often did students use concrete or virtual manipulatives to explore problems before you provided direct instruction?
STIBMI-4	How often did you ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?
STIBMI-8	How often did you assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?
STIBMI-9	How often did you use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?

A3: Cooperating Teacher Inquiry-Based Mathematics Instruction Initial Scale (CTIBMI)

Item #	Item Text	Included in Refined Scale?
CTIBMI-1	How often did your cooperating teacher begin lessons with a real-world problem for students to explore using their own strategies before the cooperating teacher demonstrated a solution?	No
*CTIBMI-2	How often did your cooperating teacher begin lessons by demonstrating a procedure before having students solve similar problems using the same procedure?	No
CTIBMI-3	How often did students use concrete or virtual manipulatives to explore problems before your cooperating teacher provided direct instruction?	Yes
CTIBMI-4	How often did your cooperating teacher ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	Yes
*CTIBMI-5	How often did your cooperating teacher immediately demonstrate the solution when students were frustrated or confused?	No
CTIBMI-6	How often did your cooperating teacher ask students to explain their mathematical reasoning beyond sharing the steps they followed to arrive at an answer?	No
*CTIBMI-7	How often did your cooperating teacher's lessons emphasize procedural steps for getting the correct answer rather than conceptual understanding?	No
CTIBMI-8	How often did your cooperating teacher assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	Yes
CTIBMI-9	How often did your cooperating teacher use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	Yes

*indicates recoding prior to analysis

A4: CTIBMI Refined Scale (4 items retained)

Item #	Item Text
CTIBMI-3	How often did students use concrete or virtual manipulatives to explore problems before your cooperating teacher provided direct instruction?
CTIBMI-4	How often did your cooperating teacher ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?
CTIBMI-8	How often did your cooperating teacher assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?
CTIBMI-9	How often did your cooperating teacher use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?

A5: Student Teacher Perceived Instructional Autonomy Scale (STPIA)

All items were retained

Item #	Item Text	Included in Refined Scale?
STPIA-1	I had the freedom to incorporate my own ideas into mathematics lesson plans.	Yes
*STPIA-2	I was expected to strictly follow my cooperating teacher's teaching methods.	Yes
STPIA-3	My cooperating teacher allowed me to modify lessons to match my teaching style.	Yes
STPIA-4	I felt comfortable teaching mathematics in a way that aligned with my beliefs about best teaching practices.	Yes
*STPIA-5	I felt pressured to teach in a way that aligned with my cooperating teacher's preferences.	Yes
*STPIA-6	I felt that I had limited input in how mathematics lessons were taught in the classroom.	Yes
STPIA-7	My cooperating teacher supported my decisions about how to adjust instruction during mathematics lessons.	Yes
*STPIA-8	I felt restricted by my cooperating teacher in the way I taught mathematics, especially when using methods different from their preferred approach.	Yes

*indicates recoding prior to analysis

A6: Inquiry-Based Math Teaching Efficacy Initial Scale (IBMTE)

Item #	Item Text	PIBMTE or IBMTOE Sub-scale?
IBMTE-1	I can teach mathematics concepts effectively using an inquiry-based approach.	PIBMTE
IBMTE-2	I understand the various mathematical strategies and tools students use to solve problems.	No
IBMTE-3	My use of inquiry-based instruction can increase motivation in students who are usually unengaged.	IBMTOE
IBMTE-4	My use of inquiry-based instruction can improve students' problem-solving skills, even if they struggle initially.	IBMTOE
IBMTE -5	I understand mathematics concepts well enough to teach elementary mathematics effectively using an inquiry-based approach.	PIBMTE
IBMTE-6	My use of inquiry-based instruction can help all students develop conceptual understanding, regardless of their current level of math proficiency.	IBMTOE
IBMTE -7	I can effectively manage student behavior during an inquiry-based lesson.	IBMTOE
IBMTE-8	My use of inquiry-based instruction can encourage perseverance in problem-solving, even for students who usually give up quickly.	IBMTOE
IBMTE-9	I can effectively facilitate student collaboration during open-ended problem-solving tasks.	PIBMTE
IBMTE-10	I can effectively ask open-ended questions that help assess my students' understanding and identify misconceptions as they explore problems.	PIBMTE
IBMTE-11	My use of inquiry-based instruction can improve students' ability to explain their mathematical reasoning to others.	No
IBMTE-12	My use of inquiry-based instruction can support student learning, even when they lack strong foundational math skills.	IBMTOE
IBMTE-13	I can effectively adapt my questioning based on the strategies students use to deepen their understanding of the problem.	PIBMTE

A7: Inquiry-Based Math Teaching Outcome Expectancy Refined Scale (IBMTOE) (6 items retained)

Item #	Item Text
IBMTOE-1	My use of inquiry-based instruction can increase motivation in students who are usually unengaged.
IBMTOE-2	My use of inquiry-based instruction can improve students' problem-solving skills, even if they struggle initially.
IBMTOE-3	My use of inquiry-based instruction can help all students develop conceptual understanding, regardless of their current level of math proficiency.
IBMTOE-4	I can effectively manage student behavior during an inquiry-based lesson.
IBMTOE-5	My use of inquiry-based instruction can encourage perseverance in problem-solving, even for students who usually give up quickly.
IBMTOE-6	My use of inquiry-based instruction can support student learning, even when they lack strong foundational math skills.

A8: Personal Inquiry-Based Math Teaching Efficacy Refined Scale (PIBMTE) (5 items retained)

Item #	Item Text
PIBMTE-1	I can teach mathematics concepts effectively using an inquiry-based approach.
PIBMTE-2	I understand mathematics concepts well enough to teach elementary mathematics effectively using an inquiry-based approach.
PIBMTE-3	I can effectively facilitate student collaboration during open-ended problem-solving tasks.
PIBMTE-4	I can effectively ask open-ended questions that help assess my students' understanding and identify misconceptions as they explore problems.
PIBMTE-5	I can effectively adapt my questioning based on the strategies students use to deepen their understanding of the problem.

A9: Qualifying Questions

Thank you for your interest in the study. Click here to read the informed consent form. After reading it, you can decide if you would like to continue with the study.

I have read the informed consent and agree to participate in the survey.
Yes No

Are you currently, or have you within the last 60 days, been a preservice teacher completing your **final student teaching semester**?

Yes No

Did you complete your student teaching in a **cooperating teacher's K-5 classroom**? (A cooperating teacher is the teacher of record who continues to teach in the classroom when you finish your student teaching hours.)

Yes No

Did you teach **mathematics** as part of your student teaching experience?

Yes No

A10: Demographic Questions

What is your gender:

Male Female Non-binary Prefer not to say

What is your age?

18-23 24-29 30-35 36-41 42-47 48 or older

prefer not to say

Select the University where you completed your teacher preparation program:

(universities listed from drop down)

Select the description that best fits your teacher education degree program:

Most of my courses were in person

Most of my courses were online

I had an equal number of courses online and in-person

Other

Select the description that best fits the district where you completed your student teaching:

Urban Suburban Rural If unsure, list your district and state below

In what grade level(s) did you complete your student teaching:

Kindergarten First grade Second grade Third grade Fourth grade Fifth grade

During your student teaching semester, approximately how many math lessons did you teach?

Less than 11 lessons 11-20 21-30 31-40 41-50 More than 50

While teaching mathematics, what was the average class size?

Less than 10 students 11-15 students 16-20 students 21-25 students

26-30 students More than 30 students

Select the structure of your teaching assignment:

Departmentalized (taught the same core subject(s) to multiple groups of students

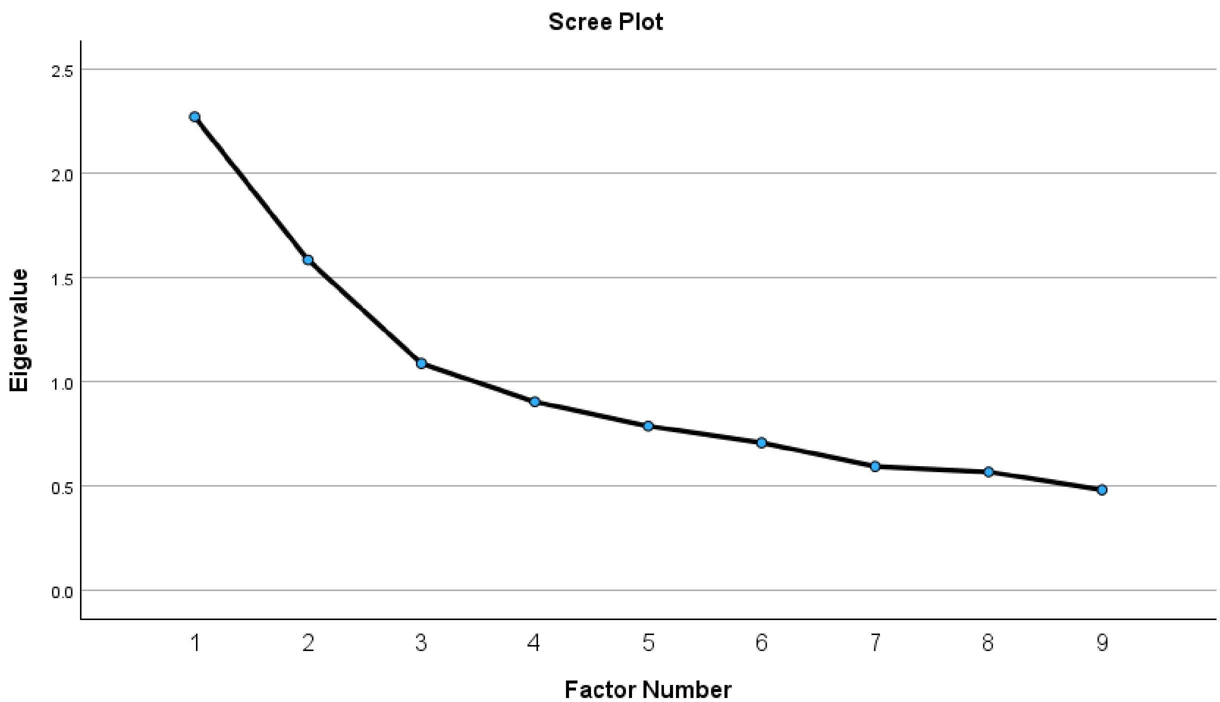
Self-Contained (taught all core subjects to one group of students)

Other

Have you worked with your cooperating teacher before student teaching and if so, in what capacity?

Appendix B - STIBMI Scale Development

B1: STIBMI Scree Plot



B2: STIBMI Total Variance Explained

Total Variance Explained

Factor	Initial Eigenvalues Total	Initial Eigenvalues % of Variance	Initial Eigenvalues Cumulative %	Extraction Sums of Squared Loadings Total	Extraction Sums of Squared Loadings % of Variance	Extraction Sums of Squared Loadings Cumulative %	Rotation Sums of Squared Loadings[a] Total
1	2.273	25.256	25.256	1.653	18.362	18.362	1.570
2	1.586	17.624	42.880	.946	10.509	28.871	.942
3	1.089	12.102	54.982	.461	5.117	33.988	.843
4	.906	10.061	65.043				
5	.789	8.766	73.809				
6	.709	7.880	81.689				
7	.596	6.619	88.308				
8	.569	6.322	94.630				
9	.483	5.370	100.000				

Extraction Method: Principal Axis Factoring.

a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

B3: STIBMI Pattern Matrix

Pattern Matrix[a]

	Factor		
	1	2	3
ST9:How often did you use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	.705		
ST3:How often did students use concrete or virtual manipulatives to explore problems before you provided direct instruction?	.593		
ST8:How often did you assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	.476		
ST4:How often did you ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	.466		
ST1:How often did you begin lessons with a real-world problem for students to explore using their own strategies before you demonstrated a solution?			
ST2_RECODE		.509	
ST7_RECODE		.494	
ST6:How often did you ask students to explain their mathematical reasoning beyond sharing the steps they followed to arrive at an answer?			-.597
ST5_RECODE		.406	-.487

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 15 iterations.

B4: STIBMI Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
ST3:How often did students use concrete or virtual manipulatives to explore problems before you provided direct instruction?	8.72	3.104	.432	.191	.575
ST4:How often did you ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	8.00	3.380	.348	.123	.628
ST8:How often did you assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	8.19	2.885	.431	.197	.576
ST9:How often did you use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	8.09	2.798	.498	.252	.525

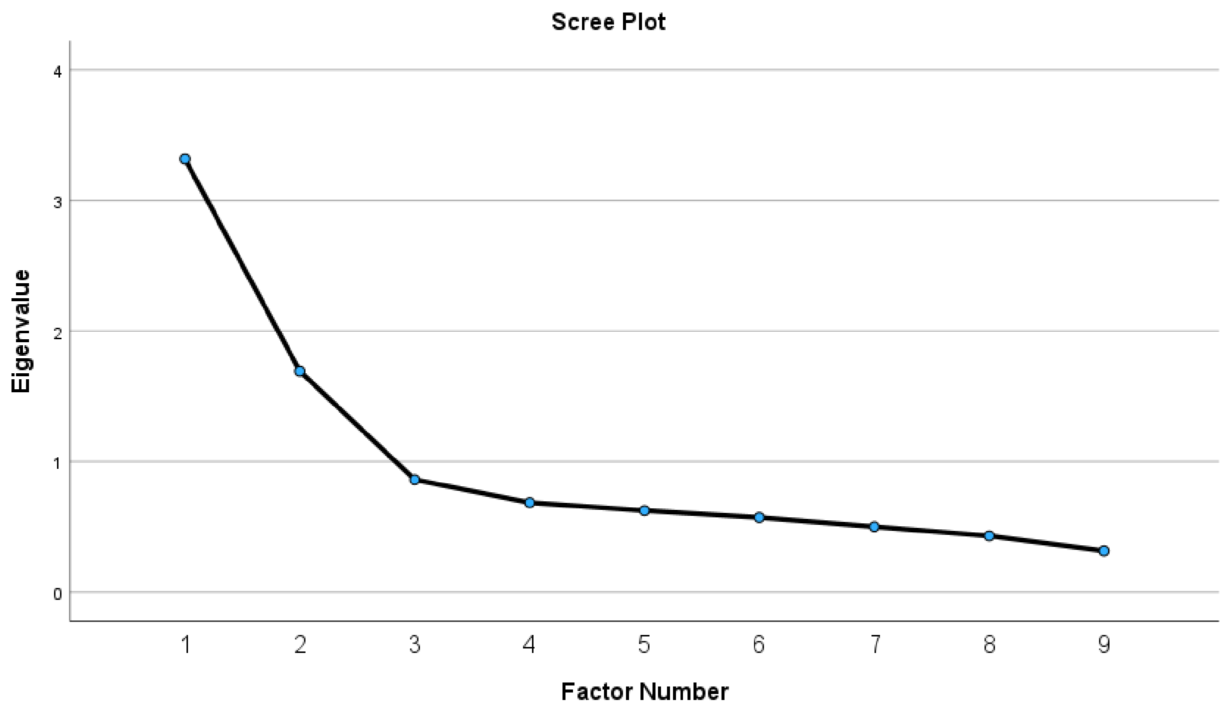
B5: STIBMI Item Statistics

Item Statistics

	Mean	Std. Deviation	N
ST3:How often did students use concrete or virtual manipulatives to explore problems before you provided direct instruction?	2.28	.760	130
ST4:How often did you ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	3.00	.726	130
ST8:How often did you assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	2.81	.845	130
ST9:How often did you use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	2.91	.821	130

Appendix C - CTIBMI Scale Development

C1: CTIBMI Scree Plot



C2: CTIBMI Total Variance Explained

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3.316	36.846	36.846	2.772	30.802	30.802	2.677
2	1.692	18.803	55.649	1.148	12.750	43.552	1.497
3	.861	9.571	65.220				
4	.686	7.618	72.838				
5	.624	6.939	79.777				
6	.572	6.350	86.127				
7	.501	5.569	91.696				
8	.431	4.785	96.481				
9	.317	3.519	100.000				

Extraction Method: Principal Axis Factoring.

a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

C3: CTIBMI Pattern Matrix

Pattern Matrix[a]

	Factor	
	1	2
CT4:How often did your cooperating teacher ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	.784	
CT6:How often did your cooperating teacher ask students to explain their mathematical reasoning beyond sharing the steps they followed to arrive at an answer?	.774	
CT9:How often did your cooperating teacher use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	.646	
CT8:How often did your cooperating teacher assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	.627	
CT3:How often did students use concrete or virtual manipulatives to explore problems before your cooperating teacher provided direct instruction?	.501	
CT1:How often did your cooperating teacher begin lessons with a real-world problem for students to explore using their own strategies before the cooperating teacher demonstrated a solution?	.484	
CT7_RECODE		.732
CT5_RECODE		.605
CT2_RECODE		.439

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 6 iterations.

C4: CTIBI Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
CT3:How often did students use concrete or virtual manipulatives to explore problems before your cooperating teacher provided direct instruction?	8.19	4.420	.494	.277	.706
CT4:How often did your cooperating teacher ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	7.59	3.995	.551	.326	.674
CT8:How often did your cooperating teacher assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	7.71	4.193	.520	.292	.692
CT9:How often did your cooperating teacher use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	7.80	3.944	.576	.350	.659

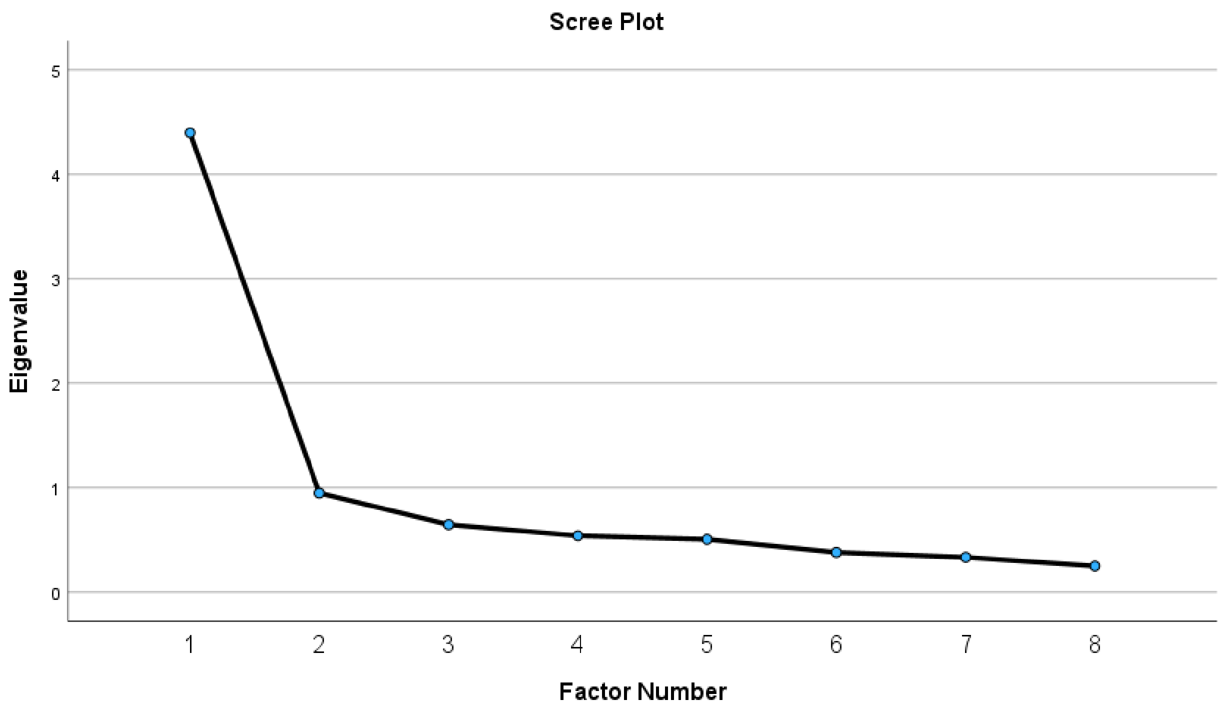
C5: CTIBMI Item Statistics

Item Statistics

	Mean	Std. Deviation	N
CT3:How often did students use concrete or virtual manipulatives to explore problems before your cooperating teacher provided direct instruction?	2.24	.815	130
CT4:How often did your cooperating teacher ask open-ended questions while students were exploring a problem to assess their thinking and misconceptions?	2.84	.896	130
CT8:How often did your cooperating teacher assess students based on their problem-solving strategies and/or their mathematical reasoning rather than just their final answer?	2.72	.863	130
CT9:How often did your cooperating teacher use student-generated representations (manipulatives, drawings, equations, etc.) to facilitate discussions about mathematical ideas?	2.63	.890	130

Appendix D - STPIA Scale Development

D1: STPIA Scree Plot



D2: STPIA Total Variance Explained

Total Variance Explained

Factor	Initial Eigenvalues Total	Initial Eigenvalues % of Variance	Initial Eigenvalues Cumulative %	Extraction Sums of Squared Loadings Total	Extraction Sums of Squared Loadings % of Variance	Extraction Sums of Squared Loadings Cumulative %
1	4.396	54.947	54.947	3.895	48.685	48.685
2	.948	11.854	66.800			
3	.647	8.081	74.882			
4	.540	6.745	81.627			
5	.505	6.312	87.939			
6	.381	4.763	92.702			
7	.334	4.176	96.878			
8	.250	3.122	100.000			

Extraction Method: Principal Axis Factoring.

D3: STPIA Pattern Matrix

Factor Matrix[a]

	Factor 1
PA5_RECODE	.763
PA7:My cooperating teacher supported my decisions about how to adjust instruction during mathematics lessons.	.753
PA3:My cooperating teacher allowed me to modify lessons to match my teaching style.	.736
PA2_RECODE	.725
PA8_RECODE	.702
PA6_RECODE	.684
PA4:I felt comfortable teaching mathematics in a way that aligned with my beliefs about best teaching practices.	.611
PA1:I had the freedom to incorporate my own ideas into mathematics lesson plans.	.587

Extraction Method: Principal Axis Factoring.

a. 1 factors extracted. 4 iterations required.

D4: STPIA Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
PA1:I had the freedom to incorporate my own ideas into mathematics lesson plans.	23.2615	20.536	.550	.335	.876
PA3:My cooperating teacher allowed me to modify lessons to match my teaching style.	23.0462	19.982	.685	.570	.862
PA4:I felt comfortable teaching mathematics in a way that aligned with my beliefs about best teaching practices.	23.1692	20.700	.566	.410	.874
PA7:My cooperating teacher supported my decisions about how to adjust instruction during mathematics lessons.	22.9308	20.329	.699	.568	.861
PA2_RECODE	23.1154	19.715	.676	.520	.862
PA5_RECODE	23.1462	19.180	.710	.586	.859
PA6_RECODE	23.1000	19.440	.638	.494	.867
PA8_RECODE	22.8692	20.084	.652	.494	.865

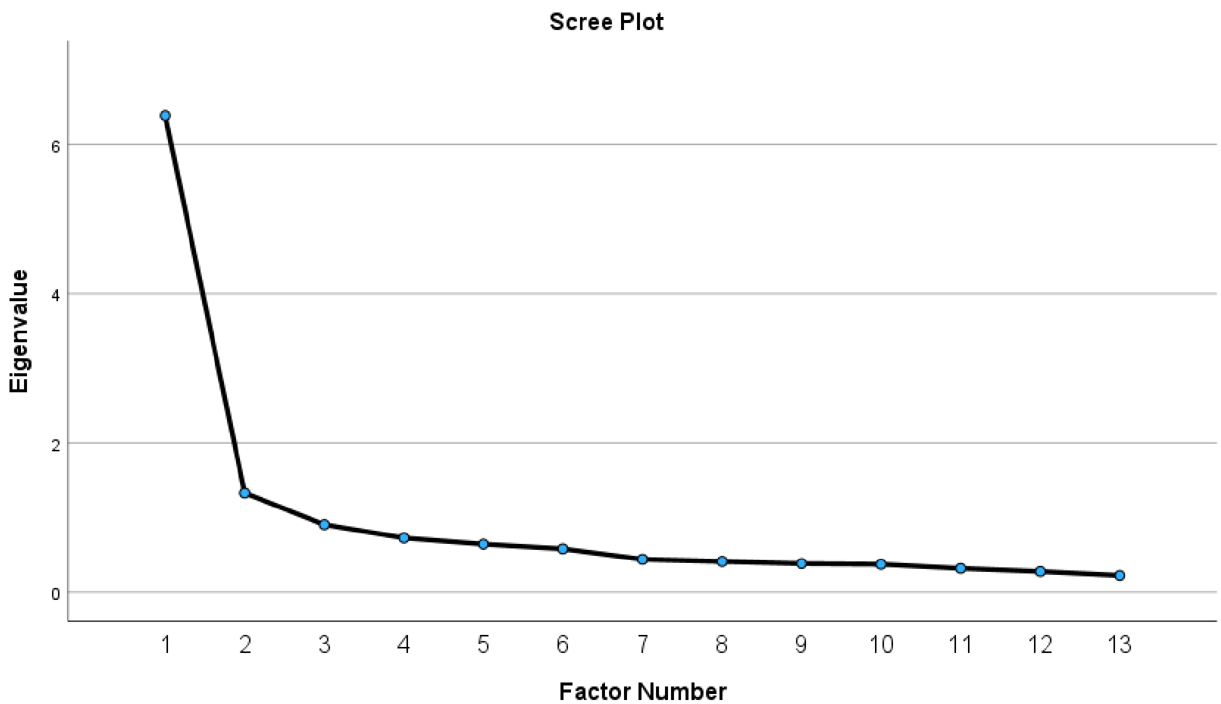
D5: STPIA Item Statistics

Item Statistics

	Mean	Std. Deviation	N
PA1:I had the freedom to incorporate my own ideas into mathematics lesson plans.	3.1154	.87723	130
PA3:My cooperating teacher allowed me to modify lessons to match my teaching style.	3.3308	.82018	130
PA4:I felt comfortable teaching mathematics in a way that aligned with my beliefs about best teaching practices.	3.2077	.83244	130
PA7:My cooperating teacher supported my decisions about how to adjust instruction during mathematics lessons.	3.4462	.75802	130
PA2_RECODE	3.2615	.86762	130
PA5_RECODE	3.2308	.91107	130
PA6_RECODE	3.2769	.94840	130
PA8_RECODE	3.5077	.83755	130

Appendix E - IBMTE Scale Development

E1: IBMTE Scree Plot



E2: IBMTE Total Variance Explained

Total Variance Explained

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.385	49.115	49.115	5.916	45.507	45.507	4.958
2	1.329	10.220	59.335	.911	7.005	52.512	4.810
3	.905	6.958	66.293				
4	.727	5.589	71.883				
5	.644	4.952	76.834				
6	.580	4.463	81.297				
7	.440	3.386	84.684				
8	.411	3.165	87.849				
9	.383	2.950	90.799				
10	.374	2.878	93.676				
11	.319	2.457	96.133				
12	.278	2.137	98.270				
13	.225	1.730	100.000				

Extraction Method: Principal Axis Factoring.

a. When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

E3: IBMTE Pattern Matrix

Pattern Matrix[a]

	Factor	
	1	2
EF4:My use of inquiry-based instruction can improve students' problem-solving skills, even if they struggle initially.	.890	
EF3:My use of inquiry-based instruction can increase motivation in students who are usually unengaged.	.767	
EF8:My use of inquiry-based instruction can encourage perseverance in problem-solving, even for students who usually give up quickly.	.733	
EF7:I can effectively manage student behavior during an inquiry-based lesson.	.549	
EF12:My use of inquiry-based instruction can support student learning, even when they lack strong foundational math skills.	.495	
EF6:My use of inquiry-based instruction can help all students develop conceptual understanding, regardless of their current level of math proficiency.	.470	
EF10:I can effectively ask open-ended questions that help assess my students' understanding and identify misconceptions as they explore problems.		.825
EF13:I can effectively adapt my questioning based on the strategies students use to deepen their understanding of the problem.		.779
EF9:I can effectively facilitate student collaboration during open-ended problem-solving tasks.		.715
EF1:I can teach mathematics concepts effectively using an inquiry-based approach.		.502
EF5:I understand mathematics concepts well enough to teach elementary mathematics effectively using an inquiry-based approach.		.486
EF11:My use of inquiry-based instruction can improve students' ability to explain their mathematical reasoning to others.	.328	.428
EF2:I understand the various mathematical strategies and tools students use to solve problems.	.323	.392

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 19 iterations.

Appendix F - IBMTOE and PIBMTE Scale Development

F1: IBMTOE Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
EF4:My use of inquiry-based instruction can improve students' problem-solving skills, even if they struggle initially.	15.18	9.532	.704	.549	.831
EF3:My use of inquiry-based instruction can increase motivation in students who are usually unengaged.	15.38	9.384	.614	.480	.845
EF8:My use of inquiry-based instruction can encourage perseverance in problem-solving, even for students who usually give up quickly.	15.43	8.712	.770	.598	.816
EF7:I can effectively manage student behavior during an inquiry-based lesson.	15.51	8.965	.658	.449	.837
EF12:My use of inquiry-based instruction can support student learning, even when they lack strong foundational math skills.	15.49	9.167	.610	.408	.846
EF6:My use of inquiry-based instruction can help all students develop conceptual understanding, regardless of their current level of math proficiency.	15.43	9.363	.586	.383	.850

F2: IBMTOE Item Statistics

Item Statistics

	Mean	Std. Deviation	N
EF4:My use of inquiry-based instruction can improve students' problem-solving skills, even if they struggle initially.	3.30	.666	130
EF3:My use of inquiry-based instruction can increase motivation in students who are usually unengaged.	3.11	.770	130
EF8:My use of inquiry-based instruction can encourage perseverance in problem-solving, even for students who usually give up quickly.	3.05	.781	130
EF7:I can effectively manage student behavior during an inquiry-based lesson.	2.98	.821	130
EF12:My use of inquiry-based instruction can support student learning, even when they lack strong foundational math skills.	2.99	.821	130
EF6:My use of inquiry-based instruction can help all students develop conceptual understanding, regardless of their current level of math proficiency.	3.05	.800	130

F3: PIBMTE Item-Total Statistics

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
EF10:I can effectively ask open-ended questions that help assess my students' understanding and identify misconceptions as they explore problems.	12.51	5.678	.636	.439	.812
EF13:I can effectively adapt my questioning based on the strategies students use to deepen their understanding of the problem.	12.53	5.383	.725	.529	.788
EF9:I can effectively facilitate student collaboration during open-ended problem-solving tasks.	12.54	5.429	.629	.434	.815
EF1:I can teach mathematics concepts effectively using an inquiry-based approach.	12.82	5.403	.639	.451	.812
EF5:I understand mathematics concepts well enough to teach elementary mathematics effectively using an inquiry-based approach.	12.58	5.718	.608	.399	.820

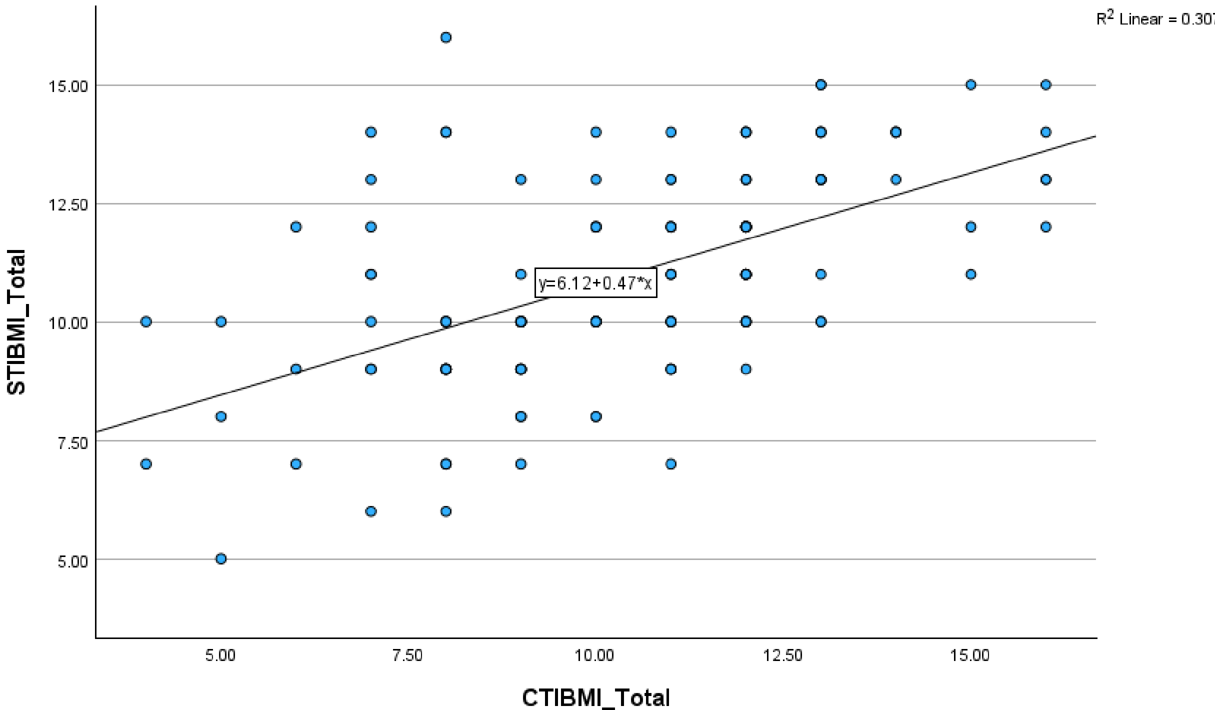
F4: PIBMTE Item Statistics

Item Statistics

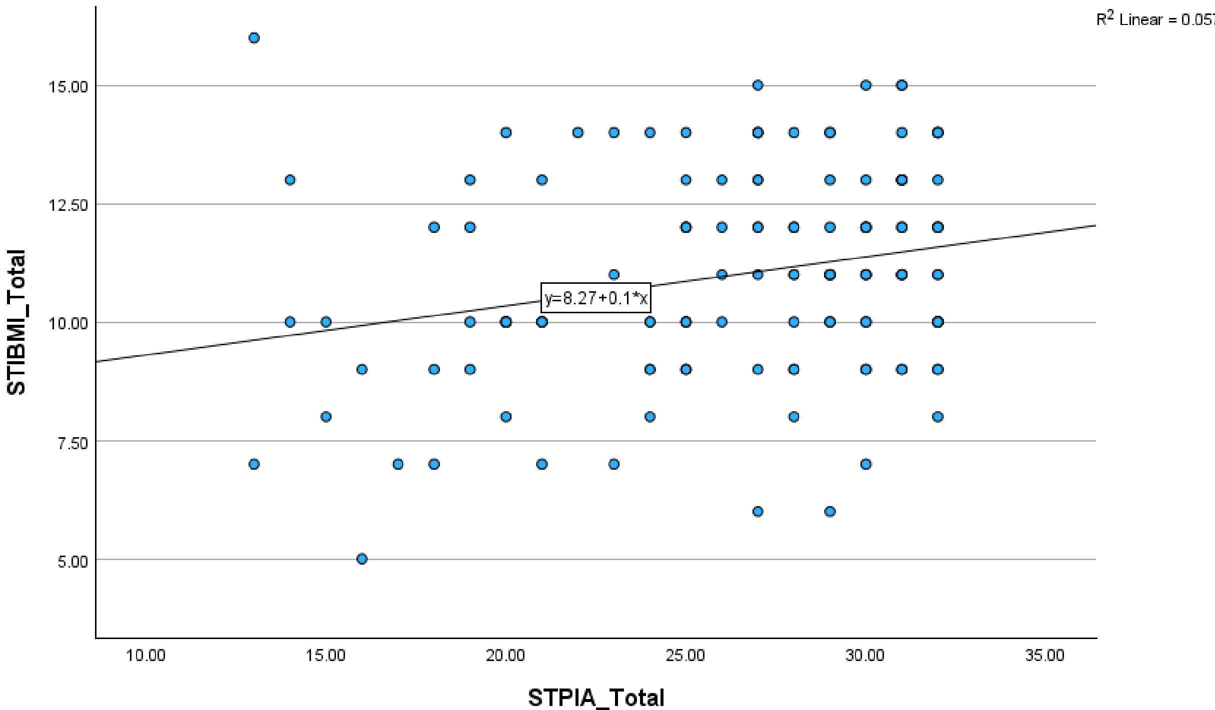
	Mean	Std. Deviation	N
EF10:I can effectively ask open-ended questions that help assess my students' understanding and identify misconceptions as they explore problems.	3.24	.702	130
EF13:I can effectively adapt my questioning based on the strategies students use to deepen their understanding of the problem.	3.22	.715	130
EF9:I can effectively facilitate student collaboration during open-ended problem-solving tasks.	3.21	.775	130
EF1:I can teach mathematics concepts effectively using an inquiry-based approach.	2.92	.774	130
EF5:I understand mathematics concepts well enough to teach elementary mathematics effectively using an inquiry-based approach.	3.16	.713	130

Appendix G - Descriptions of Data

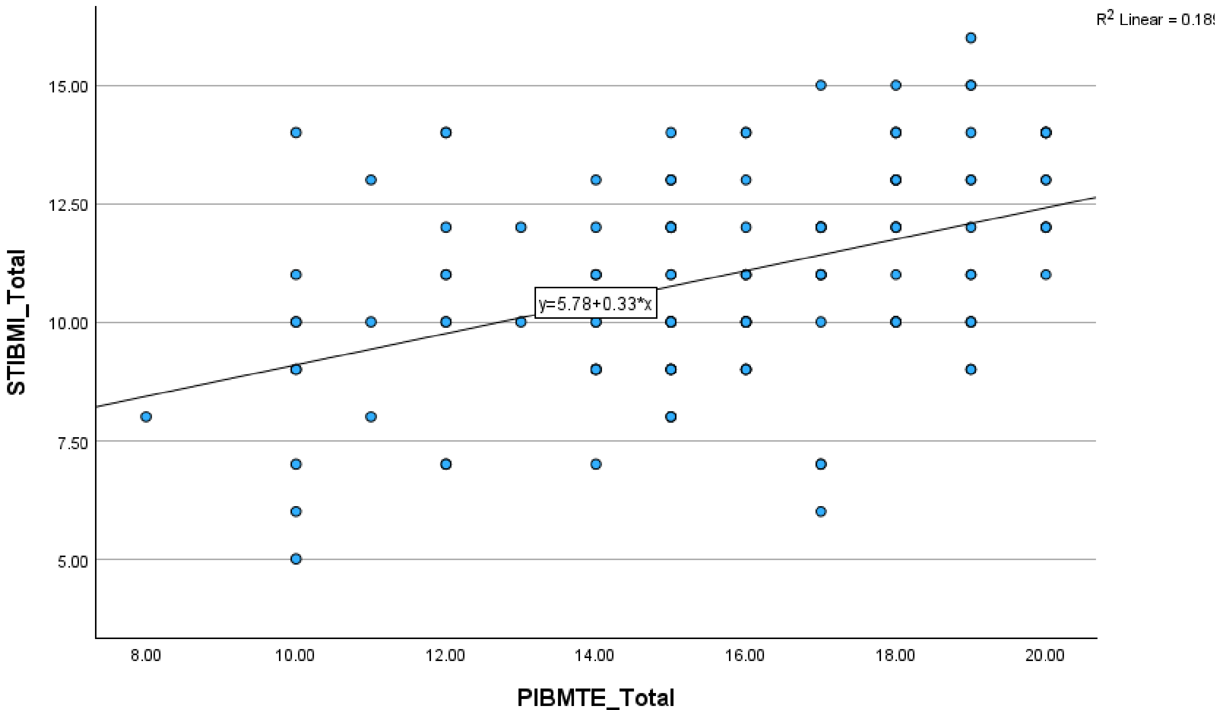
G1: Scatter plot of STIBMI and CTIBMI showing linearity



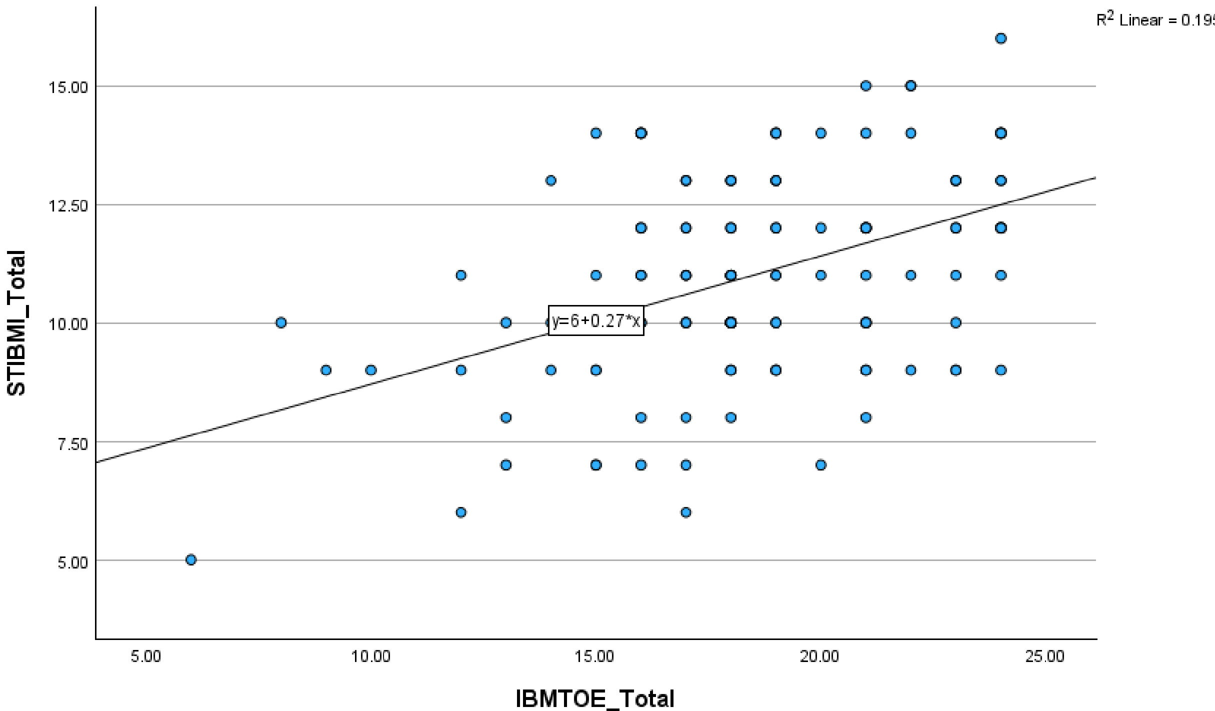
G2: Scatter plot of STIBMI and STPIA showing weak linearity



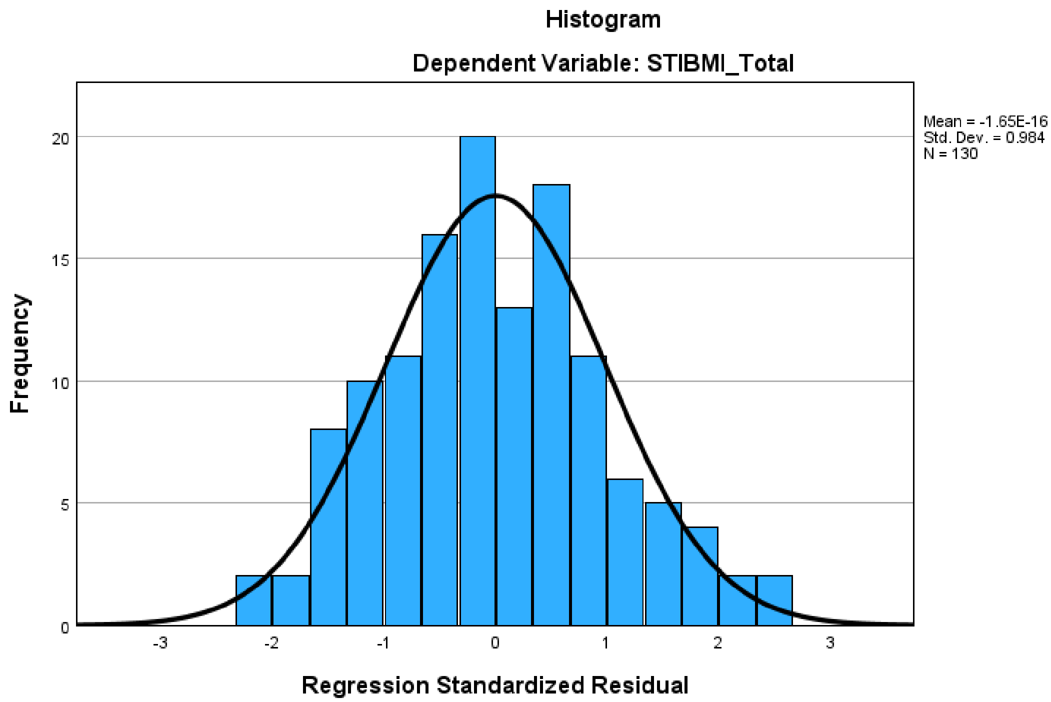
G3: Scatter plot of STIBMI and PIBME showing linearity



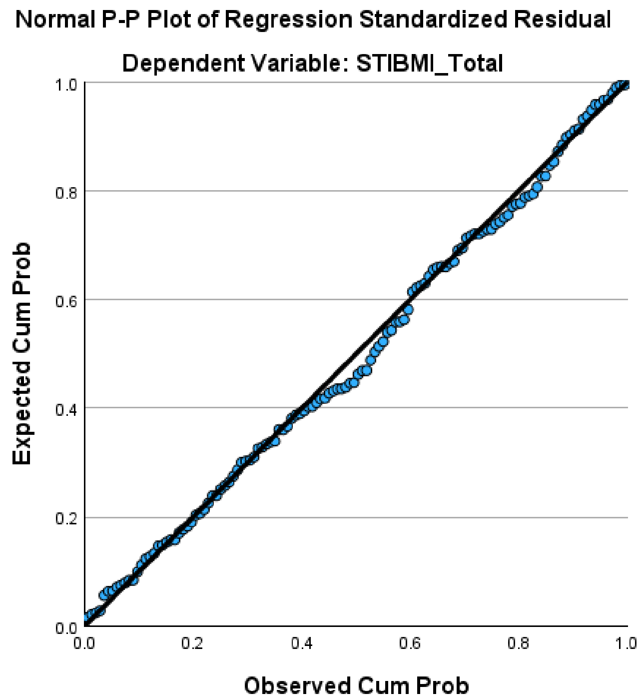
G4: Scatter plot of STIBMI and IBMTOE showing linearity



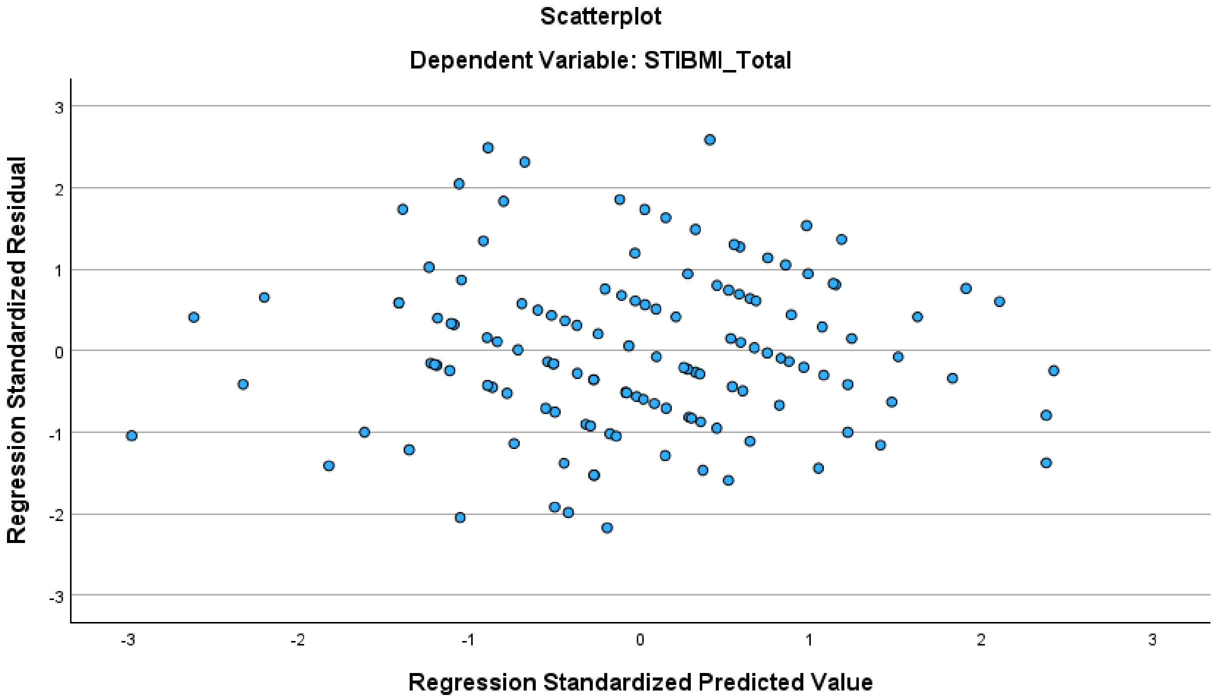
G5: Histogram of Regression Standardized Residuals



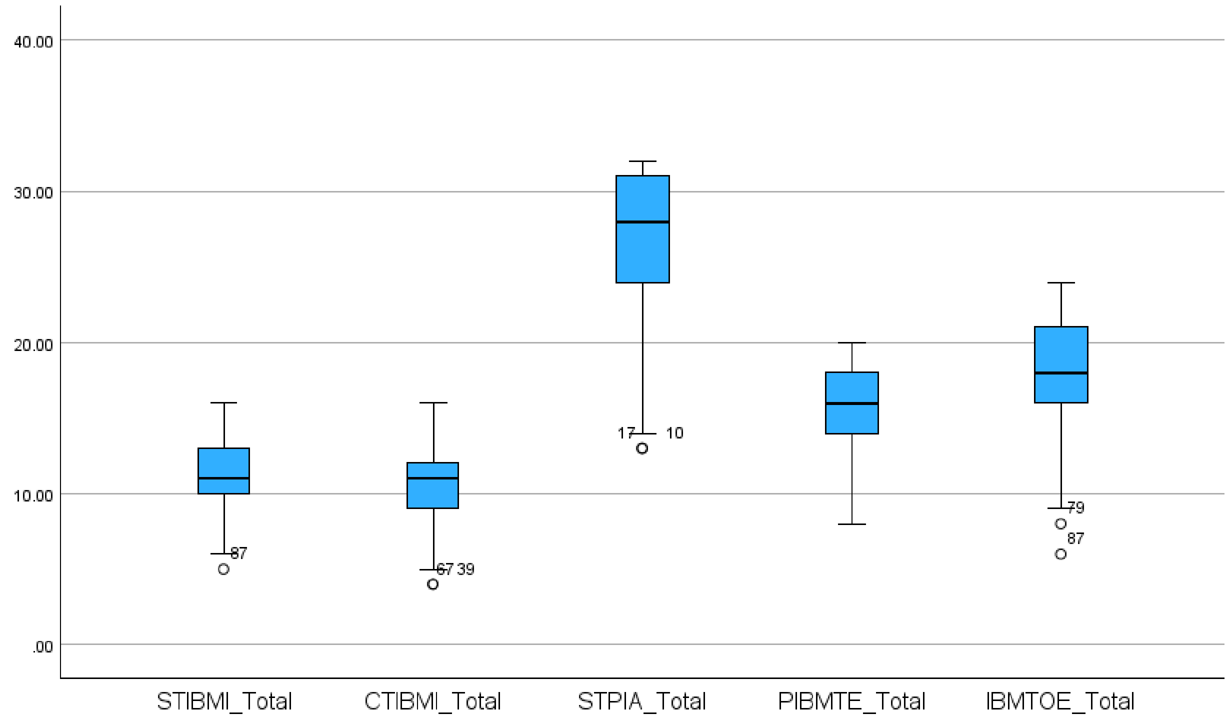
G6: Probability-Probability Plot of Regression Standardized Residuals



G7: Scatterplot of Regression Standardized Residual vs. Standardized Predicted Values



G8: Boxplot of Outliers



G9: Residuals Statistics

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	6.7883	14.4224	11.0000	1.41361	130
Std. Predicted Value	-2.979	2.421	.000	1.000	130
Standard Error of Predicted Value	.172	.600	.322	.096	130
Adjusted Predicted Value	7.0377	14.4881	10.9999	1.41136	130
Residual	-3.72421	4.42532	.00000	1.68490	130
Std. Residual	-2.176	2.585	.000	.984	130
Stud. Residual	-2.208	2.726	.000	1.007	130
Deleted Residual	-3.83471	4.92066	.00011	1.76283	130
Stud. Deleted Residual	-2.243	2.800	.001	1.015	130
Mahal. Distance	.314	14.839	3.969	3.070	130
Cook's Distance	.000	.166	.009	.019	130
Centered Leverage Value	.002	.115	.031	.024	130

a. Dependent Variable: STIBMI_Total

Appendix H- Descriptive Statistics for Each Variable

Statistics

		STIBMI_Total	CTIBMI_Total	STPIA_Total	PIBMTE_Total	IBMTOE_Total
N	Valid	130	130	130	130	130
	Missing	0	0	0	0	0
Mean		11.0000	10.4308	26.3769	15.7462	18.4846
Median		11.0000	11.0000	28.0000	16.0000	18.0000
Mode		10.00	12.00	32.00	15.00	18.00
Std. Deviation		2.19937	2.60274	5.06740	2.88087	3.58774
Variance		4.837	6.774	25.679	8.299	12.872
Range		11.00	12.00	19.00	12.00	18.00
Minimum		5.00	4.00	13.00	8.00	6.00
Maximum		16.00	16.00	32.00	20.00	24.00

Appendix I - IRB Approval

Kansas State University | Office of Research Integrity, Compliance and Security

TO: Sherri Martinie
Curriculum and Instruction
Manhattan, KS 66506

FROM: Lisa Rubin, Chair
Committee on Research Involving Human Subjects

DATE: 04/09/2025

RE: Proposal #IRB-12495, entitled "Student teachers and inquiry-based mathematics instruction: The impact of observation, efficacy, and autonomy."

MODIFICATION OF IRB PROTOCOL #IRB-12495, ENTITLED, "Student teachers and inquiry-based mathematics instruction: The impact of observation, efficacy, and autonomy"

EXPIRATION DATE: Exempt

The Committee on Research Involving Human Subjects (IRB) has reviewed and approved the request identified above as a modification of a previously approved protocol. **Please note that the original expiration remains the same.**

All approved IRB protocols are subject to continuing review at least annually, which may include the examination of records connected with the project. Announced in-progress reviews may also be performed during the course of this approval period by a member of the University Research Compliance Office staff. Unanticipated adverse events involving risk to subjects or to others must be reported immediately to the Chair of the IRB, and / or the URCO

It is important that your human subjects activity is consistent with submissions to funding / contract entities. It is your responsibility to initiate notification procedures to any funding / contract entity of any changes in your activity that affects the use of human subjects.

Electronically signed by Lisa Rubin on 04/09/2025 2:24 PM ET

203 Fairchild Hall, 1601 Vattier St., Manhattan, KS 66506 | 785-532-3224 | fax: 785-532-3278 | comply@k-state.edu