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The Effect of Instructional Strategies On Math Anxiety and Achievement: A Mixed Methods Study Of Preservice Elementary Teachers

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THE EFFECT OF INSTRUCTIONAL STRATEGIES ON MATH ANXIETY AND ACHIEVEMENT: A MIXED METHODS STUDY OF PRESERVICE ELEMENTARY TEACHERS

by

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ABSTRACT

THE EFFECT OF INSTRUCTIONAL STRATEGIES ON MATH ANXIETY AND ACHIEVEMENT: A MIXED METHODS STUDY OF PRESERVICE ELEMENTARY TEACHERS

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This study addressed how different instructional strategies affected preservice elementary teachers' levels of math anxiety and their achievement in a math content course while considering descriptions of their experiences in the course in relation to their math anxiety and achievement. The instructional strategies used were traditional teaching methods and inquiry-based learning (IBL). A mixed methods embedded design was used in which the major design of the study is a nonequivalent control group design, where the collection of data occurred before, during, and after the intervention. There were 103 participants who were elementary education preservice teachers with 58 of them being enrolled in traditional teaching sections of the course and 45 being enrolled in IBL sections. Participants completed the Mathematics Anxiety Rating Scale – Short Version (MARS-S) at the beginning and end of the course to measure their level of math anxiety. They also completed a 20-item content knowledge assessment to measure their level of achievement pre- and post-intervention. Participants' journal entries throughout the semester contained self-reported measures of math anxiety and understanding of course content as well as descriptions of their experiences in the course regarding their anxiety and understanding. Statistical tests, including two-way repeated measures ANOVA and *t*-tests, were performed to test for differences within and between the traditional and IBL groups. Significant results showed that as the semester progressed, the math anxiety of IBL participants decreased, whereas the math anxiety of traditional participants increased. Differences between the groups in terms of their level of achievement were not significant even though within both groups, participants experienced significant learning gains. By the end of the semester, statistical tests revealed that the IBL participants had significantly more positive opinions on their classroom experiences and preferences in mathematics classrooms. Correlational analysis was performed that showed a significant negative relationship between math anxiety and achievement. Random samples of each journal entry were selected, and thematic analysis was performed. The common themes that were identified as impacting participants' anxiety and understanding of course material included course content, teaching methods, assessment, and student behaviors.

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DEDICATION

I would like to thank all of those who supported and encouraged me along the way.

To my husband, Mike, and our three sons, Nathan, Eric, and Adam: Thank you for putting up with all of my stressed craziness without killing me.

To my family and friends: Thank you for always being there to help with the boys so I could work in peace.

To my colleagues Dr. Daniel Acosta and Mr. Ryan Dutsch: Thank you for leading the focus group sessions.

To my students: Thank you for participating in the study. I hope it opened your eyes as it did mine to how impactful the instructional strategy used in a math classroom can be to students.

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LIST OF ABBREVIATIONS

ATTMQ	Anxiety Towards Teaching Mathematics Questionnaire
CBMS	Conference Board of Mathematical Sciences
CCSS	Common Core State Standards
CCSSM	Common Core State Standards for Mathematics
IBL	Inquiry-based Learning
MARS	Mathematics Anxiety Rating Scale
MARS-S	Mathematics Anxiety Rating Scale Short Version
MTEBI	Mathematics Teaching Efficacy Belief Instrument
NCTM	National Council of Teachers of Mathematics
RTOP	Reformed Teaching Observation Protocol

CHAPTER I - INTRODUCTION

Introduction

Instructors of mathematics content courses for preservice elementary teachers in higher education institutions often find themselves trying to meet the needs of both the mathematics and education departments on their campuses. These mathematics instructors are responsible for providing a firm foundation in elementary mathematics content, while education instructors emphasize pedagogical skills these teaching candidates will one day need to be able to effectively teach the content. Not only is communication between the two departments essential but so is coherence between how mathematics is actually being taught in the math classroom and what students are learning about how to teach mathematics in their education courses. When preservice elementary teachers are taught mathematics under an instructional strategy based on the learning theory of constructivism, then they will gain firsthand knowledge and experience of effective math teaching and learning practices (Conference Board of Mathematical Sciences, 2012). Although research has shown that inquiry-based approaches to teaching have been effective in deepening students' conceptual understanding of mathematics content, it is also believed that these types of approaches may lessen students' math anxiety (Gresham, 2007; Lubinski & Otto, 2004; Sloan, 2010).

On either side of the so-called "Math Wars" exists two very different types of educators with varying opinions on what is the best way to teach mathematics – the behaviorists and the constructivists. According to Brahier (2013), the behaviorist perspective has roots in the works of Thorndike and Skinner. Behaviorist learning theory emphasizes the role of external rewards and punishments in shaping human behavior. In the classroom setting, high scores on an assessment may be considered a type of reward, whereas bad grades may be considered a punishment. When students are rewarded, they would be more likely to repeat those actions; however, when they are punished, the likelihood that the action would be repeated decreases. Traditional teaching methods, such as direct instruction, are typically found being used by teachers who believe in the behaviorist theory of learning. In a traditional math class, it is common to find the teacher working examples at the board while the students passively take notes. The students' minds are viewed as being blank slates in which the teacher's job is to etch knowledge upon them. Emphasis is often placed on procedural fluency of mathematical algorithms through repeated practice, thus coining the math teaching technique more commonly known as *drill and kill* (Brahier, 2013). Even though traditional teaching strategies have been used in math classes for decades, research has shown that these methods may result in students who seldom inquire in the classroom, engage in reasoning and sense-making, or think of themselves as problem solvers (Boaler, 2008). In previous research, preservice elementary teachers have reported that their math anxiety was caused by having to complete timed tests, math classes being boring, course material being taught too quickly, and a heavy emphasis placed on obtaining the correct answer (Harper & Daane, 1998). All of these are characteristics often found in classes focused on traditional teaching methods.

The learning theory of constructivism is based on the work of Jean Piaget and Lev Vygotsky and is the leading theory of learning today (Brahier, 2013). The idea behind constructivism is that students construct their own knowledge and that it is not possible to passively transmit knowledge from one person to another (Latterell, 2005). Deep understanding of concepts, discovery learning, and communication among classmates are at the core of constructivism (Brooks & Brooks, 1999; Fosnot & Perry, 2005; Latterell, 2005). In order to maximize learning, students are encouraged to raise questions, compare and contrast their processes and ideas, and experience disequilibrium in their thinking (Brahier, 2013; Collins, 2002; Fosnot & Perry, 2005; Schifter, 2005). An instructional strategy often found in higher education constructivist classrooms is inquiry-based learning (IBL). In an IBL classroom, the instructor acts as a facilitator by guiding students through a series of problems. While characteristics of IBL classrooms will vary, most place emphasis on self-discovery of mathematical content, minimal lectures if any at all, communication between students and the instructor, alternative assessments, and students' presentations of problems (Schinck, 2014). Research has shown that classes promoting active learning reduce the number of students who fail or withdraw from a course; result in higher learning gains, particularly for low-achieving students; and improve students' understanding of and self-confidence in doing mathematics (Freeman et al., 2014; Kogan & Laursen, 2013; Laursen & Hassi, 2012; Smith, Ware, Cochran, & Shores, 2009).

There is no denying that many math content courses are taught following traditional teaching techniques; however, when it comes to content courses for preservice teachers, research and the Conference Board of Mathematical Sciences (CBMS) recommends a more student-centered approach. The CBMS suggests that preservice teachers complete a minimum of 12 semester hours of mathematics focused on quality instruction and mathematics content covering the entire elementary mathematics curriculum, including the Common Core State Standards for Mathematics and the

Common Core Standards of Mathematical Practice. Furthermore, these courses should encourage preservice teachers to develop the habits of mathematical thinking and problem solving, such as reasoning quantitatively and abstractly, explaining and modeling mathematics, being precise in their computations, and constructing valid arguments. The teaching style should be flexible, nurturing, and interactive with plenty of opportunities for preservice teachers to feel successful in solving challenging problems (CBMS, 2012). Research regarding the design of mathematics content courses emphasizes features of quality mathematics courses. These features include having preservice teachers reflect upon their own learning, providing opportunities for students to use mathematics in a variety of contexts, emphasizing conceptual understanding and reasoning, encouraging students to work collaboratively, and making connections between mathematical content knowledge and pedagogical content knowledge (Lubinski & Otto, 2004; Mestre & Cocking, 2002; Thanheiser, Browning, Moss, Watanabe, & Garza-Kling, 2010).

Hembree (1990) found that preservice elementary teachers suffered from higher levels of math anxiety than other college majors. Thus, it is of the utmost importance that those responsible for teaching mathematics courses for preservice teachers understand the causes of math anxiety and the ways in which it can be reduced. Math anxiety can be defined as being a state of discomfort that one experiences when involved in situations requiring the use of mathematics and can affect people of all ages (Ashcraft, 1995; Cemen, 1987; Wu, 2014). Those who suffer from math anxiety perceive mathematical tasks as being threatening to their self esteems and may also experience physical changes such as tension, sweaty palms, difficulty breathing, and inability to concentrate

(Burns,1998; Bursal & Paznokas, 2006; Dutton & Dutton, 1991; Hembree, 1990; Trujillo & Hadfield, 1999). The causes of math anxiety among preservice teachers can be traced to their previous experiences in math courses. Through interviews with students, researchers found that students attributed the onset of their anxiety to math classes that are boring and taught too quickly, having to complete timed tests, having too much emphasis placed on obtaining the correct answer, a lack of confidence in their mathematical ability, negative parental influences, or a focus on memorization of procedural knowledge (Harper & Daane, 1998; Sloan, 2010; Swars, Daane, & Giesen, 2006). Preservice teachers who suffer from math anxiety are likely to have lower math achievement and negative beliefs regarding their confidence to learn and teach mathematics (Ashcraft, 1995; Ashcraft & Krause, 2007; Bursal & Paznokas, 2006; Swars et al., 2006; Wu, Willcutt, Escovar, & Menon, 2014). Methods that have been found to reduce math anxiety include class discussions, whole and small group work, and using manipulatives (Gresham, 2007; Harper & Daane, 1998; Sloan, 2010; Vinson, 2001).

Statement of the Problem

Research has shown that preservice elementary teachers have the highest level of math anxiety of any other college major (Hembree, 1990). If the math anxiety is not brought to their attention and reduced prior to beginning their teaching careers, these preservice teachers are likely to become school teachers with math anxiety. Students with math anxious teachers are likely to experience poor mathematics teaching focused on algorithmic procedures, insufficient time spent on mathematics in the classroom, and the development of math anxiety themselves (Buhlman & Young, 1982; Karp, 1988, 1991; Middleton & Spanias, 1999; Scholfield, 1981). The National Council of Teachers of Mathematics recommends that the elementary mathematics curriculum emphasize conceptual understanding in addition to procedural fluency; however, the Third International Mathematics and Science Study showed that many elementary teachers lack the kind of deep understanding of mathematics that is required to teach mathematics conceptually (Mullis, Martin, Gonzalez, & Chrostowski, 2004; Smith et al., 2009). Mathematics methods courses for preservice teachers often emphasize conceptual understanding and inquiry in the K-12 classroom based on recommendations from the National Council of Teachers of Mathematics (Sloan, 2010). Perhaps if mathematics content courses for preservice teachers emphasized the conceptual understanding and inquiry as well, then the cycle of math anxiety being passed from teacher to student could be broken as teaching candidates strengthen their mathematical understanding.

Math anxiety among preservice elementary teachers is quite common and has serious consequences on their future students' understanding and success in the mathematics classroom (Buhlman & Young, 1982; Karp, 1988, 1991; Middleton & Spanias, 1999; Scholfield, 1981). Although several studies have been conducted that consider the causes of math anxiety and methods to reduce it in preservice elementary teachers, the majority of these students are completed in the context of mathematics method courses instead of content courses (Gresham, 2007; Harper & Daane, 1998; Perry, 2011; Sloan, 2010; Swars et al., 2006; Trujillo & Hadfield, 1999; Vinson, 2001). Also, little research has been conducted on IBL in mathematics content courses designed specifically for preservice elementary teachers. Research has shown that more than one inquiry course is needed to have a positive, beneficial impact on students (Smith et al., 2009). Thus, waiting until preservice teachers enroll in a methods course may be too late to introduce these teaching candidates to IBL. One study by Alsup (2004) considered how instructional strategy impacted preservice teachers' levels of math anxiety. However, it was strictly quantitative in nature; and the courses with the different instructional strategies were two different courses focused on different course content. A need exists in the literature to examine the effects of instructional strategy on preservice teachers' levels of math anxiety and achievement not only through quantitative measures, but also through detailed, qualitative descriptions from the participants.

Purpose of the Study

This study addressed how different instructional strategies affected preservice elementary teachers' levels of math anxiety and their achievement in a math content course while considering descriptions of their experiences in the course in relation to their math anxiety and achievement. The general goal of this project was to determine if instructional strategies that employ IBL are more effective at reducing preservice elementary teachers' levels of math anxiety while increasing student achievement. A mixed methods embedded design was used in which the major design of the study is a nonequivalent control group design, where the collection of data occurred before, during, and after the intervention. Qualitative data were collected from students through the use of questionnaires, journals, and focus groups. The single independent variable was the type of instructional strategy employed by the course instructor. The two types of instructional strategies that were used were traditional lecture methods and IBL. The dependent variables were the students' math anxiety level as measured by the Mathematics Anxiety Rating Scale Short Version (MARS-S), their self-reported math anxiety from journal entries, their achievement as measured by a test of their mathematics content knowledge, and their self-reported level of understanding from journal entries. All participants were undergraduate students majoring in elementary education and were enrolled in one of four sections of Math 277 Mathematics for Elementary and Middle School Education II at Southeastern Louisiana University during the Fall 2015 semester.

Theoretical Framework

While instructional strategies focused on traditional teaching methods and IBL do not have specific pedagogies of their own, they do draw their strength from the behaviorist learning theory and constructivism. According to Brahier (2013), behaviorist learning theory is rooted in the works of Thorndike and Skinner, who both believed that a person's behavior can be shaped due to external punishments and rewards. Behaviorist mathematics classrooms are often teacher-centered, place an emphasis on memorization and procedural fluency, and discourage peer communication (Brahier, 2013). On the other hand, the theory of constructivism is based on the work of Piaget and Vygotsky. They believed that a person constructs his/her own knowledge based upon his/her previous knowledge and experiences and that information cannot be passively transmitted from one person to another (Brahier, 2013; Latterell, 2005). Features of student-centered, constructivist mathematics classrooms include an emphasis on conceptual understanding and problem solving, whole and small group discussions, and self-discovery and independence in learning (Brooks & Brooks, 1999; Fosnot & Perry, 2005; Latterll, 2005).

Research Questions

The following questions were investigated in this research study.

1. As measured by the Mathematics Anxiety Scale Short Version (MARS-S), what effect do different instructional strategies have on preservice teachers' levels of math anxiety?

2. As measured by pre- and post-tests of preservice teachers' mathematical content knowledge, what effect do different instructional strategies have on preservice teachers' mathematics achievement?

3. How do preservice teachers describe their experiences in Math 277 with regard to their math anxiety and mathematics achievement?

Research Hypotheses

Research questions 1 and 2 were investigated through statistical data analysis of the following research hypotheses.

Research Hypothesis 1: The preservice teachers who are enrolled in the courses with IBL as the instructional strategy will experience a significant decrease in their levels of math anxiety as compared to the preservice teachers who are enrolled in the courses with traditional teaching methods as the instructional strategy.

Research Hypotheses 2: The preservice teachers who are enrolled in the courses with IBL as the instructional strategy will experience a significant increase in their achievement levels as compared to the preservice teachers who are enrolled in the courses with traditional teaching methods as the instructional strategy.

Limitations and Delimitations

This research was conducted with the following limitations and delimitations.

- The study was delimited to only one course instructor for the four classes. The results of the study may not generalize to other instructors.

- The study was limited to only preservice elementary school teachers who self-enrolled in the researcher's mathematics content course based on their scheduling needs. Student assignments to class sections were not random. The results of the study may not generalize to students with other college majors or those enrolled in other mathematics courses.
- This study was delimited to the assignments of the IBL and traditional groups. The researcher intentionally kept the classes that met on Mondays and Wednesdays the same format (randomly selected to be traditional), whereas the classes that met on Tuesdays and Thursdays were also the same format (randomly selected to be IBL)
- The study was limited to primarily female students. Approximately 96% of the students were female. The results of the study may not generalize to classes in which the majority of the students are not female.
- The study was limited by its short time frame. The study was conducted over the course of one semester. The course in which the participants were enrolled is the 2nd course in a 3-course sequence.
- The study was limited by the honesty and clarity of the participants' responses on questionnaires, journal entries, and focus groups.

Assumptions

The study was conducted with the following assumptions under consideration.

- It was assumed that all of the participants answered truthfully and accurately to the questions asked of them in the questionnaires, to their journal prompts, and in the focus groups discussions.

- It was assumed that all of the participants responded honestly to the best of their individual abilities based on their personal experiences in the course.

Definition of Terms

Behaviorist Learning Theory: A learning theory in which it is believed that a physical stimulus, such as external punishments and rewards, affects a person's behavioral responses (Brahier, 2013; Fosnot & Perry, 2005)

Common Core State Standards for Mathematical Practice: A set of eight process standards that teachers should encourage in their students in order for them to develop the habits of mind of mathematicians (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2015a)

Common Core State Standards of Mathematics: A set of academic standards that address the mathematical content that all students in grades kindergarten through high school are expected to achieve by the end of each grade (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2015a)

Conceptual understanding: When students display conceptual understanding, then they "understand which ideas are key (by being helped to draw inferences about those ideas) and that they grasp the heuristic value of those ideas" (Wiggins, 2014). Students are able to solve both routine and non-routine problems while avoiding common errors and connecting ideas. (Wiggins, 2014)

Constructivism: A learning theory in which it is believed that that students construct their own knowledge and that it is not possible to passively transmit knowledge from one person to another (Brahier, 2013; Latterell, 2005)

Inquiry-based learning (IBL): An instructional strategy that emphasizes student-centered learning, collaboration and communication among classmates, and independence and rigor in problem solving (Schick, 2014)

Instructional strategy: Techniques and methods used by teachers in order to help their students learn

Math 277: A required course of all preservice teachers majoring in PK-8 education at Southeastern Louisiana University. The course name is Mathematics for Elementary and Middle School Education II. The course is the second class in a 3-course sequence and covers topics such as fractions, decimals, ratio, proportion, probability, and data analysis. Students are permitted to use a scientific calculator for only the probability and data analysis units.

Math Anxiety: A state of discomfort that one experiences when involved in situations requiring the use of mathematics that can affect people of all ages - from elementary school children to adults (Ashcraft, 1995; Cemen, 1987; Wu et al., 2014). Many who suffer from math anxiety perceive mathematical tasks as being threatening to their self esteems and may also experience physical changes such as tension, sweaty palms, difficulty breathing, and inability to concentrate (Burns,1998; Bursal & Paznokas, 2006; Dutton & Dutton, 1991; Hembree, 1990; Trujillo & Hadfield, 1999)

National Council of Teachers of Mathematics (NCTM): The largest professional organization in the world for mathematics educators. The mission of NCTM is to be the "public voice of mathematics education, supporting teachers to ensure equitable mathematics learning of the highest quality for all students through vision, leadership, professional development, and research" (National Council of Teachers of Mathematics, 2015)

Preservice elementary teacher: A college student who is majoring in elementary education in order to receive teaching certification in the elementary grades, typically from kindergarten to fifth grade (CBMS, 2012)

Problem solving: In the context of mathematics classes, problem solving refers to mathematical tasks that provide students with opportunities to challenge their thinking while improving their understanding of mathematical concepts. (National Council of Teachers of Mathematics, 2000)

Traditional teaching methods: A teacher-centered instructional strategy that tends to focus heavily on direct instruction and practicing isolated mathematics skills and procedures without much emphasis on conceptual understanding of topics (Latterell, 2005)

CHAPTER II – REVIEW OF THE LITERATURE

Introduction

This study addressed how different instructional strategies affected preservice elementary teachers' levels of math anxiety and their achievement in a math content course while considering descriptions of their experiences in the course in relation to their math anxiety and achievement. A review of the relevant literature regarding this study is presented in this chapter. The topics in this literature review include discussions of popular learning theories and their related classroom instructional strategies, professional recommendations for the design and implementation of mathematics content courses for preservice elementary teachers, and math anxiety as it applies to preservice elementary teachers.

Learning Theories

How people learn has been the topic of many debates over the past hundreds of years by philosophers, psychologists, and teachers. What exactly is learning? Depending upon who is asked, one may receive many different answers. Learning can be defined as "knowledge or skill acquired by instruction or study" (Merriam-Webster Online Dictionary, 2015). Jackson (1986) reports that learning is often thought of to be a mimetic activity in which the ultimate goal is it repeat new information on some form of assessment, such as tests or reports. Fosnot (1993) states that "Learning is not discovering more, but interpreting through a different scheme or structure" (p. 8). Teachers' definitions of learning can easily be influenced by the educational learning theory that resonates most closely with them. In mathematics education, teachers may side with the behaviorist learning theory and tend to teach in a more traditional, teacher-centered manner; whereas others adopt the learning theory of constructivism, resulting in student-centered, reform classrooms. This dichotomy of traditional vs. reform instructional strategies makes up what is referred to as the “math wars” (Latterell, 2005).

Behaviorist Learning Theory

In the United States from the 1920s to 1970s, the leading learning theory was based on the behaviorist theory of psychology (Brahier, 2013). According to Fosnot and Perry (2005), behaviorists believe a physical stimulus affects a person’s behavioral responses; thus, it is believed that external punishments and rewards can control one’s learning (Brahier, 2013). Two psychologists, E.L. Thorndike and B.F. Skinner, were the pioneers of behaviorist learning theory. In the early 1900s, Thorndike proposed two principles regarding human learning theory – the law of exercise and the law of effect. The law of exercise states that the more a behavior is repeated, the more strongly that it is learned; whereas the law of effect states that stimuli that result in positive responses increase the likelihood of the behavior being repeated. On the other hand, stimuli that result in negative responses are less likely to be repeated. Years later, Skinner further refined the work of Thorndike and discovered that rewards did not need to be given any time a stimulus resulted in a positive reaction and that it was possible for rewards to be given infrequently and randomly. Skinner also learned that it was possible to shape behaviors (Collins, 2002). In terms of education, psychologists who work within the behaviorist theory of learning are interested in how reinforcement, external motivation, and practice affect students’ learning (Fosnot & Perry, 2005).

In a classroom where behaviorist learning theory is being implemented, the students are viewed as being passive learners who are waiting for knowledge to be provided to them by the teacher and are affected by reinforcement (Collins, 2002; Skinner, 1953). It is assumed that students will learn best through observing the teacher, listening to the teacher's explanations, and participating in experiences in which teacher feedback is provided, all while the teacher emphasizes part-to-whole direct instruction (Bloom, 1956; Gagne, 1965). Thus, teachers develop well-structured and sequenced curriculum focused on hierarchical behavioral objectives that range from simple to complex (Collins, 2002; Fosnot & Perry, 2005). According to Collins (2002), behavioral objectives "are always written in terms of how many students will achieve the desired response at what level of success in what amount of time" (p.7). It is assumed that students will progress in a linear fashion so long as the teacher provides ample practice, reinforcement, and motivation (Fosnot & Perry, 2005). The well-known instructional method of drill and practice in math classes has its roots in behaviorist learning theory (Collins, 2002). Furthermore, students are assessed on predetermined tasks where high scores on the assessments might represent a reward and low scores might be a punishment that would encourage students to work even harder to learn the skill so that they would eventually earn a reward (Brahier, 2013).

From an educational perspective, behaviorist learning theory has several attractive features. First, teaching methods that fall under behaviorist learning theory are simple to implement and familiar to many teachers. Also, behaviorist learning theory is based on controlled research by psychologists such as Thorndike and Skinner, and it can be used to explain several phenomena related to learning (Collins, 2002). However, behaviorist learning theory does not take into account students' internal motivation, their cognitive change, and what is actually happening in the minds of the students when learning takes place (Brahier, 2013; Collins, 2002; Fosnot & Perry, 2005). Even though behaviorist learning theory was popular for many years, its significance in the field of education began to wane as other phenomena related to learning were unable to be explained strictly by behaviorist learning theory (Collins, 2002).

Constructivism

Another frequently used term to describe human learning is constructivism (Collins, 2002). The idea behind constructivism is that students construct their own knowledge based on their interactions with the environment and that it is not possible to passively transmit knowledge from one person to another (Brahier, 2013; Latterell, 2005). Deep understanding of concepts and discovery learning are at the core of constructivism unlike with behaviorist learning theory where imitative behaviors and teaching by telling are common (Brooks & Brooks, 1999; Fosnot & Perry, 2005; Latterell, 2005). Constructivism and behaviorist learning theory are interpreted as being in direct opposition to each other (Fosnot & Perry, 2005). Constructivists believe that learning is a complex, nonlinear, active process in which self-organization, reflection, and discussions are essential (Brahier, 2013; Collins, 2002; Fosnot & Perry, 2005). Learning is viewed as a social process in which opportunities are provided for students to raise questions, compare and contrast their processes and ideas with their peers and teachers, and experience disequilibrium in their thinking in order to maximize learning (Brahier, 2013; Collins, 2002; Fosnot & Perry, 2005; Schifter, 2005).

Origins of Constructivism. One of the most influential figures behind constructivism was psychologist Jean Piaget, even though he never actually used the term constructivism himself (Brahier, 2013; Brooks & Brooks, 1999). The beginnings of the theory of constructivism occurred in the 1960s when Piaget and his colleagues began to research the mechanics of learning and the processes that allowed new perspectives, or constructions, to develop (Fosnot & Perry, 2005). Piaget believed that the way people learn about the world in which we live occurs both through individuals' experiences and maturation over time (Brooks & Brooks, 1999). Even though Piaget's research focused primarily on children and Piaget never directly applied his research to education, later researchers explained how aspects of Piaget's research could be applied to the classroom (Fosnot & Perry, 2005; McLeod, 2015).

One particular psychologist, Lev Vygotsky, developed his own theory regarding how people learn. Vygotsky's theory, which is entitled cognitive mediation, emphasizes that a child's learning is strongly influenced by his interactions with others (Watson, 2002). There are two important aspects of Vygotsky's theory: (a) people construct knowledge and (b) learning impacts a person's development (Davidson & Davidson, 1994). According to Watson (2002), "Learning comes first and brings about development." Vygotsky believed that in order for learning to occur, learners must create their own personal representations of any new information they receive. Learners can be assisted in this process by constructing knowledge based upon the knowledge of and their interactions with others (Davidson & Davidson, 1994). At the core of Vygotsky's theory is the concept of a zone of development. The lower level of the zone, which is called the actual level of development, consists of things that a child can complete independently. The upper level of the zone, which is called the potential level of development, consists of things that a child is incapable of achieving (Watson, 2002). Between these two levels is the zone of proximal development, which Vygotsky defined as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (as cited in Frawley, 1997, p. 101). It is within this zone of proximal development that a teacher must focus.

Constructivism in the Classroom. A constructivist approach in the classroom is one that focuses on the student and requires a great amount of skill on the parts of teachers to be effectively implemented in a classroom environment (Brahier, 2013). Although constructivist learning theory does not prescribe a single teaching method, many teaching strategies can be incorporated into the classroom that are aligned to constructivist ideas (Fosnot & Perry, 2005). Brooks and Brooks (1999) provide many characteristics of teachers and classroom environments in which constructivism drives the learning process. First, classroom environments should be designed so that students are free to think, explore, and engage in relevant discussions. Students are assessed during daily interactions with the teacher, not just on tests at the end of a unit of material. Challenging, open-ended problems that are focused on big ideas of concepts and are relevant to the students should be assigned as it will deepen students' long-term understanding. Furthermore, constructivist teachers encourage student independence, creativity, and inquiry; allow students' questions and discussions to influence and even alter lessons; and rely heavily on primary resources, manipulatives, and interactive materials.

The central ideas behind constructivism are supported by the National Council of Teachers of Mathematics (NCTM). Curricula promoted by the NCTM are constructivist in nature and emphasize students' discovering mathematics and using multiple representations to solve problems and construct their own knowledge of mathematical concepts (NCTM, 2008). Of particular importance to mathematics teachers is the idea of social constructivism, which emphasizes the importance of social interactions during the process of constructing knowledge (Latterell, 2005). It is imperative that open dialogues take place in the mathematics classroom, as well as an emphasis on students' doing mathematics, including rigorous problem-solving and inventing their own strategies to solve such problems (Latterell, 2005; Schifter, 2005).

Classroom methods such as collaborative learning and scaffolding both have roots in Vygotsky's theory (McLeod, 2014). When teachers incorporate collaborative learning into their classrooms, students work together in small groups, possibly with the assistance of the teacher, to understand and apply course material. This approach is different than the traditional format of classes that are centered on teachers' lectures. With collaborative learning, students are actively engaged in discussion of course material (Smith & MacGregor, 1992). Scaffolding in the classroom refers to the interaction between the teacher and the student while working in the zone of proximal development. At the center of the idea of scaffolding is the idea that teachers must gradually withdraw themselves from the learning process as students are able to work independently (Goos, 2004). Just as children tend to learn better in an interactive, engaging environment, preservice teachers can also benefit in a class of this form (Jacobs, 2001).

Instructional Strategies

Two common instructional strategies teachers often use in mathematics classrooms are traditional teaching methods and student-centered learning (Brahier, 2013). IBL falls under the category of student-centered learning.

Traditional Teaching Methods

The traditional teaching method in mathematics classes is consistent with behaviorist learning theory and is widespread across all grade levels - from elementary schools to post-secondary classrooms (Brahier, 2013). Unfortunately, this method has been shown to be ineffective in helping students learn mathematics (Boaler, 2008). Traditional teaching methods tend to focus heavily on direct instruction and practicing isolated mathematics skills and procedures without much emphasis on conceptual understanding of topics (Latterell, 2005). Traditional teaching is often teacher-centered, with the teacher lecturing at the board and providing example problems while the students sit passively taking notes (Brahier, 2013). This routine of the teacher demonstrating methods in the front of a classroom and then assigning similar problems for students to practice independently results in students believing that in order to be successful in math classes, they must pay careful attention to the teachers' methods and memorize algorithmic procedures (Boaler, 2008; Latterell, 2005). Not only is memorizing mathematical procedures difficult, especially if conceptual understanding is missing, but students find it difficult to apply the methods and procedures in new situations that require the use of the skill. This could result in students' failing exams and not being able to apply the mathematical concepts to real-life situations outside of the classroom (Boaler, 2008). Other features of traditional classrooms are that teachers view students' minds as blank slates waiting for knowledge to be etched upon them by the teacher, student learning is validated by answering questions correctly, students generally working alone, and assessment is separate from teaching and heavily focused on tests (Brooks & Brooks, 1999).

The heavy emphasis on memorization brought on by traditional teaching methods results in students who seldom inquire in the math classroom, engage in reasoning and sense-making, or think of themselves as problem solvers. Studies have shown that young children are natural problem solvers who are more capable of thinking mathematically before they are enrolled in formal math classes. It is believed that as students are exposed to more and more classes focusing on traditional teaching methods, those students gradually lose their problem-solving abilities, creative methods, and to some extent, common sense, in favor of following rules and procedures. This often results in the onset of frustration regarding mathematics because students are unable to truly understand the material they are learning, why the procedures work, and the relationships between important concepts. One way to remedy this problem is to assign complex, non-routine problems for students to solve that require them to communicate and explain their reasoning and methods (Boaler, 2008).

Inquiry-based Learning

Inquiry-based learning (IBL) has its roots in constructivist learning theory. In higher education, IBL refers to a student-centered approach to teaching mathematics, inspired by the work of Raymond Moore in the 1920s. The Moore Method emphasizes student independence and rigor in problem solving. Textbooks were often not used, and teacher-directed lectures rarely occurred. Moore's belief was that students who are taught the best are those who are told the least. In a Moore Method class, students would be given problems to independently solve and then present and justify their solutions to the class. Although Moore's original method is not seen often in higher education classrooms today, many instructors who implement IBL techniques in their classes use a variation of the Moore Method known as the Modified Moore Method (Schinck, 2014).

In a Modified Moore Method class, collaboration between peers is encouraged, instructors may present mini-lectures, or students might have access to either a published or teacher-created textbook. While IBL classes may all look slightly different, there are a few characteristics that are common among them. First, class often begins with students signing up to present their solutions to problems. Those students chosen for presentations either write their solutions on the white board or display them through the use of a document camera. Based on the work shown and explanation provided by the presenter, the other students in the class must decide whether or not the presented solution is valid. If a consensus is reached, then the next problem is presented. If the class is not able to agree on the solution to the presented the problem, the instructor may provide additional problems to assist the students in answering the original problem or encourage the students to work collaboratively until a solution is agreed upon. The majority of class time is often spent on student presentations, and course grades are often not solely based upon examinations but also on presentations (Schinck, 2014; Yoshinobu, 2015).

Benefits of Inquiry-based Learning. Numerous studies report on the many benefits of incorporating IBL strategies in the higher education classroom, most of which are supported by the National Science Foundation (National Science Foundation, 2014). In the largest and most comprehensive meta-analysis on active learning versus traditional instruction in undergraduate science, technology, engineering, and mathematics (STEM) courses, Freeman et al. (2014) analyzed the results of 225 research studies focusing on either traditional lecturing methods or active learning methods. The active learning methods varied greatly and included group problem solving, peer instruction, and tutorials completed during class. The criteria for admission in the meta-analysis were that the study contrasted traditional lecture and active learning methods, occurred in an undergraduate STEM class, was limited to changes in the regularly scheduled class, and provided data on the academic performance of students. Data from the studies were collected through both completely randomized trials and quasi-random designs where students were unaware of the treatment when they registered for their courses. The hypothesis they were testing was that learning and student achievement would be maximized when instructors employed lecture-based approaches. The results of the meta-analysis revealed the opposite to be true. Students enrolled in classes that are focused on active learning experienced average higher achievement scores of 6%. Furthermore, students enrolled in traditional lecture courses were 1.5 times more likely to either fail (earn a grade of D or F) or withdraw from the class than those students in classes centered around active learning. The results show that the average failure rate of students in lecture courses to be 33.8% versus 21.8% for students in active learning courses. All of the results hold true regardless of class size; however, smaller classes (those with 50 or fewer students) benefited even more than larger classes (Freeman et al., 2014). These results could have serious implications for the future of these STEM courses. With the predicted number of incoming freshmen entering STEM fields in the United States estimated to be 7 million students, that yields an estimated difference of 840,000 students who would otherwise pass a lecture-based course if only it had been taught using active learning techniques. Concerning tuition savings, a conservative estimate would be that these 840,000 students could save approximately $3,500,000 each semester (National Science Board, 2010; Snyder & Dillow, 2013). The authors define active learning to be learning that "engages students in the process of learning through activities and/or discussion in class, as opposed to passively listening to an expert. It emphasizes higher-order thinking and often involves group work" (Freeman et al., 2014, p. 8413-8414). IBL clearly falls under this definition of active learning.

The goals of a recent study by Laursen and Hassi (2012) were to determine the impact that experiences with IBL have on preservice elementary teachers' knowledge, beliefs, attitudes, and confidence. The two sites used in the study each had their own IBL Mathematics Centers and had implemented inquiry courses for preservice elementary teachers. Students in these courses were expected to solve challenging problems, work in groups or alone, present their solutions, and critique the work of others. The role of the instructors was to guide students' learning by selecting appropriate problems, manage the dynamics of the classroom, and highlight important concepts during class discussions. Participants in the study consisted of preservice elementary and secondary teachers with the majority of them being women. Participants were assessed at both the beginning and the end of the semester on several measures, including their growth in mathematical knowledge for teaching, learning gains, and attitudes toward mathematics. After experiencing an IBL mathematics course, comparative analysis of the measures from the beginning of the course to the end of the course revealed that there was a significant increase in the students' mathematics knowledge for teaching, which illustrates that the course is preparing students well for their future teaching. Also, the learning gains experienced by low- and medium-achieving students over the course of the semester were significantly higher than the learning gains experienced by the high-achieving students. These learning gains include confidence in teaching mathematics, applying mathematics, and collaboration. Although the majority of the data regarding the participants' attitudes towards mathematics were mixed, the results did show that the participants' placed less emphasis on extrinsic goals. However, there was no confidence gain in their own mathematics ability or willingness to study hard. These results could show that the students had slightly matured in the way they approached learning mathematics (Laursen & Hassi, 2012)

Smith, Ware, Cochran, and Shores (2009) were interested in the impact of implementing inquiry-based instruction in college level mathematics courses designed for pre-service elementary teachers. The two courses focused on developing deep conceptual understanding and connections of algebraic and geometric concepts while emphasizing reasoning and communication. The courses were required of students pursuing elementary teaching certification, and the participants were undergraduate students who were mostly in their early 20s with several non-traditional students as well. All of the students had previously completed courses taught using a traditional lecture format with only a few having previously taken a methods course. Assessments for the courses included performance tasks, student presentations, conversations with students, a reflective summary, and a summative portfolio. A strong emphasis was placed on writing because students were required to explain all solutions using illustrations, graphs, equations, or sentences. Data for the study were collected from focus groups consisting of faculty and preservice teachers as well as observations of faculty members incorporating inquiry in their classrooms and their students. The researchers found that students were more likely to have positive views on the inquiry nature of the courses if they had completed both of the inquiry courses instead of just one of them. Of the students who had taken both courses, most stated that they had a much deeper understanding of mathematics, increased self-confidence in their abilities, and intend to use similar approaches in their own classrooms. On the other hand, students who had only completed the first course in the sequence were more likely to experience frustration at having to teach themselves, the high amount of group work, and the lack of structure in the classroom. Results from the observation checklists reveal that students did improve on specific abilities, including understanding of mathematical ideas, productive disposition, inquiry and reflection, and communication. Faculty members reported how important students' struggling is to the learning process and that students learned by doing mathematics instead of watching someone else do mathematics. However, they did have concerns regarding class size, time restrictions, fixed syllabi, various ability levels of students, and grading. When faculty members were observed in their classrooms, those who supported IBL had considerably higher scores on the Reformed Teaching Observation Protocol (RTOP) than those who felt inquiry was too challenging to incorporate in the higher education classroom (Smith et al., 2009). The RTOP measures the degree to which teachers incorporate reformed teaching practices in their classrooms and is measured in five domains: (a) lesson design and implementation, (b) propositional knowledge, (c) procedural knowledge, (d) communicative interaction, and (e) student/teacher relationships (Sawada, 2002).

In a recent study by Kogan and Laursen (2013), the researchers considered students' grades and their future mathematics coursework after experiencing an inquiry mathematics course in which a minimum of 60% of class time was devoted to student-centered activities such as student presentations, group work, and class discussions. For those participants enrolled in non-IBL courses, at least 85% of the class time was focused on instructor lectures. The participants were all students enrolled in upper-level undergraduate mathematics courses at one of four different higher education institutions, from which data from over 40 courses and 100 class sections were collected. Several important results emerged from the data. First, the researchers learned that the grades for the IBL students were at least as good as or better than those students in non-IBL courses. Also, students enrolled in IBL classes pursued more higher-level courses, in particular, IBL courses, than the non-IBL students. In those future classes, high- and medium-achieving students who had taken a previous IBL course earned average grades that were similar to students who had not taken an IBL course; however, low-achieving students from IBL courses performed significantly better than low achievers from non-IBL courses. It can be concluded that IBL courses focused on active learning cause no harm to students in regard to their achievement in future coursework (Kogan & Laursen, 2013).

Recommendations for Mathematics Content Courses

The issue of the mathematical preparation of future elementary teachers has been an area of interest of researchers and mathematical organizations for years. However, the majority of the research done in this field is centered on preservice teachers enrolled in mathematics methods courses, not mathematics content courses. Due to an absence of a credible knowledge base in the field, this causes problems for many mathematicians who must rely on their best judgment in deciding what and how to teach in their math content courses geared toward preservice elementary teachers (Berk & Hiebert, 2009). Nor has much research been done to determine the types of learning opportunities that are effective in helping preservice teachers acquire the mathematical content knowledge required for teaching (Thanheiser et al., 2010). This is an issue of great importance because students' beliefs regarding the teaching and learning of mathematics are influenced by their own experiences in math content courses (Lubinski & Otto, 2004). Furthermore, many future elementary teachers possess weak math backgrounds of the mathematics taught in elementary and secondary school. To them, mathematics is primarily about rules and procedures, and being an effective math teacher is being able to clearly explain procedures to children. It is the responsibility of the teacher educator to recognize these views and then to dispel them by building upon what they already know in the hopes of turning preservice teachers into mathematical thinkers (CBMS, 2012, Thanheiser et al, 2010).

Conference Board of Mathematical Sciences

In 2012, the Conference Board of the Mathematical Sciences (CBMS), an umbrella organization consisting of sixteen professional organizations relating to the mathematical sciences, released its report, *The Mathematical Education of Teachers II*. This document contains recommendations to those who teach mathematics to preservice teachers regarding the mathematical knowledge these students should possess. It is clearly stated that teachers need a deeper knowledge of the mathematics they will be expected to teach; proficiency alone with elementary mathematics is not sufficient knowledge for a teacher. Furthermore, teachers must know the relationship and connections between the math they teach and the math that is taught in both prior and later grades. In order for preservice teachers to develop a solid understanding of the entire elementary mathematics curriculum, the content must be studied in depth and from the viewpoint of a teacher while correcting any misconceptions and improving any weaknesses in the students' mathematical knowledge. It is recommended that preservice elementary teachers complete a minimum of 12 semester-hours of mathematics courses designed specifically for preservice elementary teachers that focus on the "fundamental ideas of elementary mathematics, their early childhood precursors, and middle school successors" (CBMS, 2012, p. 18). These courses should focus on quality, not quantity, and be taught by either mathematicians or statisticians within an institution's mathematics department; whereas any mathematics methods courses focusing on pedagogy should be led by a mathematics educator within an institution's teaching college. Collaboration between the two departments is critical in ensuring a quality program that adequately prepares these future mathematics teachers (CBMS, 2012).

The CBMS also recommends that the mathematics coursework encourage preservice teachers to develop the habits of mathematical thinking and problem solving, just as they would expect of their own students. Adequate time must be provided in the courses in order for preservice teachers to reason, explain, model, generalize, and make sense of mathematics. Attention should be given to students monitoring their own progress while solving problems, being precise in their computations, and constructing valid arguments. Exercises in identifying flaws in students' arguments, correcting students' misunderstandings, and finding alternative solutions to problems are all beneficial to preservice teachers. Also, emphasis should be placed on preservice teachers' accuracy in using mathematical terminology and notation. A nurturing classroom environment that encourages preservice teachers to work hard and persevere at solving problems should be provided so that they can feel the satisfaction of solving a challenging problem and so that perhaps they will not protect their own students from the difficulties sometimes associated with learning mathematics. Lastly, to help develop these mathematical habits, courses should be designed so that the teaching style is both flexible and interactive, while providing the students with the opportunity to participate in research projects, field experiences, and mathematics seminars (CBMS, 2012).

With technology playing such an important role in elementary school, content courses should allow preservice teachers to utilize software, manipulatives, and other tools that support learning and teaching. By using technology as a problem-solving and computational tool, preservice teachers are able to expand their mathematical knowledge while becoming aware of the limitations of using technology. It is important that preservice teachers are exposed to a variety of mathematical tools, even if they are different than those that they may one day use with their own students. The responsibility of incorporating technology into the content courses falls on the instructor, who should demonstrate ways of using the tools while discussing any advantages and disadvantages associated with their use (CBMS, 2012).

Common Core State Standards and Teacher Preparation

The Common Core State Standards for Mathematics (CCSSM) describe mathematical skills, understandings, and practices that students are expected to acquire and develop throughout their educational careers from kindergarten to high school (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). These standards were developed as part of an initiative by the National Governors Association and the Council of Chief State School Officers in order to “define what students should understand and be able to do in their study of mathematics” (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2015a, p. 4). As of May 2015, 43 states have adopted the Common Core State Standards (Common Core State Standards Initiative, 2015b). Because the standards are unfamiliar for most preservice teachers, it is of utmost importance that they are emphasized in their content courses (CBMS, 2012).

However, the mathematics content standards are only half of the Common Core State Standards for Mathematics. The Common Core State Standards for Mathematical Practice describe eight practices related to actually doing mathematics. These practices are perseverance in problem solving, reasoning, constructing arguments and critiquing others’ reasoning, modeling with mathematics, using tools appropriately, attending to precision, looking for structure, and expressing regularity in repeated reasoning (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). These practices are closely related to the National Council of Teachers of Mathematics process standards of reasoning and proof, communication, problem solving, representations, and connections (National Council of Teachers of Mathematics, 2000). If preservice teachers are to help their future students develop the CCSS for Mathematical Practice, then they themselves must understand the practices, how they occur in school mathematics, and how they can be acquired by students. Thus, content courses that approach mathematics in a manner consistent with the CCSS for Mathematical Practice will benefit preservice teachers in developing these skills themselves. Furthermore, a new accreditation agency, the Council for the Accreditation of Educator Preparation, will require that curriculum for preservice teachers address both the CCSS for Mathematical Practice and mathematics content standards (CBMS, 2012).

As for the CCSSM content standards, courses for preservice teachers should focus on how the mathematical ideas in the elementary grades build to ideas addressed in the middle grades. Although the focus of the mathematics curriculum for preservice teachers should be on the CCSSM content areas for grades K-5, content areas introduced in the middle grades, such as ratio and proportional relationships, the number system, expressions and equations, and statistics and probability, should be included. The 12 semester-hours of recommended coursework should be divided so that 6 semester-hours focus on the area of number and operations and the other 6 semester-hours cover algebraic ideas, measurement and data, and geometry (CBMS, 2012).

Teacher Preparation Based on the Research of Learning

Mestre and Cocking (2002) present research on the leading theory of learning, constructivism, and offer suggestions on how to best conduct teacher preparation courses. Although the research focuses on the education of preservice science teachers, the information presented is also applicable to the education of preservice elementary teachers in their mathematics content courses. The authors begin with a brief summary of differences between experts and novices in terms of problem solving. Experts are able to quickly and efficiently recall their knowledge because of the highly organized, hierarchical nature in which it is stored. When experts are presented with new knowledge in their area of expertise, they integrate it into their existing knowledge banks, making it easier for them learn more all while exerting little effort. When problem solving, experts have the ability to categorize information according to major principles associated with the problem while discussing, justifying, and applying the appropriate procedures needed. On the other hand, novices tend to approach problem solving by categorizing information based on superficial characteristics of the problem while immediately jumping to finding a solution. Thus, it is important for students to be made aware of the instructor's unspoken knowledge regarding problem-solving during classroom instruction so that they are more likely to practice and apply problem-solving strategies that focus on big ideas rather than superficial attributes (Mestre & Cocking, 2002).

A priority of course instructors also should be in assisting students in organizing their content knowledge into some hierarchical structure in order to increase their proficiency of the subject matter. Furthermore, preservice teachers also need to begin building their pedagogical content knowledge so the integration of subject matter with ways of teaching the material should be incorporated into the courses. However, the teaching of quality content should be the focus of these types of courses so that students have an in-depth knowledge of mathematical ideas (Mestre & Cocking, 2002).

In the field of education, the current view of learning is that people learn best when they are given the opportunity to actively construct their own knowledge. There are two important implications of this view as they relate to the classroom. First, a student's existing knowledge must be taken into account as it affects an individual's ability to build upon that knowledge. Secondly, instructors should consider using instructional strategies that favor the construction of knowledge over those that do not, such as lecturing. Even though lecturing can be effective in certain circumstances, it is ineffective in actively involving students in the learning process. Methods that encourage students to discuss and do math, as well as teach math and offer problem-solving strategies to their peers, are helpful in achieving the goal of construction of knowledge. In situations such as these, the course instructors act as learning coaches, encouraging students to make sense of the mathematics. The authors also stress that preservice teachers often find courses that encourage them to work collaboratively to be gimmicks. If this happens, it is important for course instructors to present research suggesting that these types of approaches are superior to lecturing approaches. Another benefit to incorporating an active learning atmosphere in the classroom is that it encourages instructors to regularly use formative assessment to carefully monitor students' learning as it occurs and tailor instruction to meet the needs of the students (Mestre & Cocking, 2002).

Because many students have difficulty applying mathematics content from one course (or problem) to another, course instructors should also consider the process of transfer when teaching content courses for preservice teachers. Transfer can be defined as "the ability to apply knowledge learned in one context to a new problem or situation" (Mestre & Cocking, 2002, p. 18). Factors such as students' interest and motivation, time on task, the context in which the students' learned the knowledge, and the students' previous learning all have an effect on transfer. With transfer being difficult to accomplish, especially if employing traditional instruction, the authors have provided two ways course instructors can improve the likelihood of transfer in their students. The first method is through introducing metacognitive strategies that encourage preservice teachers to reflect about their own learning and problem-solving strategies, which can also lead to a deeper understanding of content. The authors further state that the implementation of metacognitive strategies is critical in courses that deviate pedagogically from the norm. Secondly, providing opportunities that encourage students to use mathematics content in a variety of different contexts can help make the learning last (Mestre & Cocking, 2002).

Models to Improve Elementary Teacher Preparation

Research from Berk and Hiebert (2009) describe a model that has been shown to improve the mathematical preparation of elementary teachers at the University of Delaware, where it has been implemented in each of the three required mathematics content courses for preservice elementary teachers. The model contains 3 main principles. First, essential learning goals for the preservice teachers were identified. Then, data were collected regarding the implementation of the learning goals in order to recommend changes to the lesson plans. Lastly, course lesson plans were continually updated to reflect the changes identified in the second step and stored as a shareable product among all instructors responsible for teaching the mathematics content courses. Thus, the model encourages the creation of living lesson plans in which the entire history of the lessons over the course of many semesters is documented for all instructors to review (Berk & Hiebert, 2009).

Course instructors worked collaboratively throughout all aspects of the model. The creation of the learning goals was perhaps the most crucial step in the model because it dictates the course curriculum and instructional strategies. In creating the learning goals, instructors had to consider what was necessary for the students to know. They had to consider only the essential mathematical knowledge that would be required for elementary teaching. Course instructors then had to commit to the learning goals so that appropriate instructional activities that reflect the goals could be developed and used in all sections of the courses. The instructional activities were provided in the lesson plans, which also included the learning goals; typical responses, questions, and misconceptions of the preservice teachers; suggested instructor responses; and a history of the revisions made to the lesson. When revisions to lessons were made, they were not based upon the instructors' hunches or students negative reactions to the lessons; instead, they were based upon evidence of the preservice teachers' learning, which illustrated how the course was designed to develop mathematical competencies of the students. This resulted in a gradual improvement process whose aim was to improve the curriculum rather than implement quick fixes. Based upon student participation in class and course assessments, it was decided that the revised lesson better achieved the learning goal. However, there were still more changes to be made based on difficulties students were still having. This, of course, led to another revision to be implemented the following semester (Berk & Hiebert, 2009).

A written assessment had also been developed that was administered to each of the preservice teachers at the beginning of each of the three mathematics content courses. By gathering this longitudinal data, the researchers hoped to determine whether or not the program had positive effects on the students' learning as they progressed through the program and to also identify any differences that may have existed in student learning between different cohorts of students. The results of this assessment showed that the changes made in the lesson plans have been actual improvements to the program and student learning (Berk & Hiebert, 2009).

Research by Lubinski and Otto (2004) presents a standards-based approach to teaching mathematics content courses for preservice elementary teachers in the hopes that both the experience and the content would deepen the students' knowledge of the mathematics that they would one day teach. In the course, a greater emphasis was put on deep, conceptual understanding of fewer topics as opposed to memorization of many ideas. There were three main goals of the course, with the first being to improve the preservice teachers' understanding of certain mathematical ideas. The other goals were to encourage reasoning skills and sense-making of problems and to develop a community of learners. The instructors themselves had a hurdle to overcome, and that was to dispel common student beliefs, attitudes, and perceptions that students may have regarding the study of mathematics. Some of these beliefs and attitudes that instructors believed to be present in students include thinking mathematics is about following, remembering, and applying procedures; the instructor will illustrate step-by-step how to solve problems; mathematics is not a sense-making experience; and being unsure how to study mathematics to bring about true learning, and possessing weak, unorganized mathematical knowledge. By basing the content course on recommendations from their own university as well as professional literature and reports from professional organizations regarding the teaching and learning of mathematics, the researchers were able to develop a constructivist course unlike any others the students had ever experienced. Several aspects in particular are discussed below (Lubinski & Otto, 2004).

Course instructors decided to eliminate the use of a course textbook in order to discourage students from mimicking examples and relying on algorithms and formulas to solve problems. Course content consisted of the material within 24 core problems, many with multiple parts and modifications, in which the students were encouraged to work together with their peers both inside and outside of class. There was either little or no instruction related to the materials prior to the problems being assigned to the students. In order for students to learn to trust their own mathematical thinking, course instructors primarily asked the students questions in order to probe their reasoning and led the students in class discussions related to students' reasoning. Instructors also encourage students to utilize quantitative reasoning and reflective practices regarding the strategies used in order to improve their understanding and abstract-thinking capabilities. To further emphasize the focus of the course being on problem-solving and sense-making, students were allowed to use their class notes on all of their quizzes and tests, the content of which mirrored the same concepts and strategies of that in the assigned problems. Lastly, students were assigned several graded homework assignments to further deepen their understanding and were encouraged to work cooperatively with their peers to complete them (Lubinski & Otto, 2004).

The authors provide an example of a typical type of problem the students would be required to complete. On the first day of class, students are handed the problem, "For three digits a, b, and c, the six-digit number abc,abc has what positive integers as divisors" (Lubinski & Otto, 2004, p. 341). There is no discussion on the part of the instructor, and students begin working on the problem, looking up any terms for which they may not be familiar. On the second day, the instructor begins by asking if anyone has any questions regarding the problem, being careful not to give any hints for solving it, and then asks students to offer suggestions on how to begin to solve it. If no one has any suggestions, the students are instructed to continue working on their own or in their peer groups on the problem. If a student has a suggestion, the instructor asks the student to verbalize his/her strategy and copies it to the board. At the end of the class, the instructor makes a note of the students' strategies and determines which ones to pursue during the next class. This process of having students offer strategies and justify their reasoning continue until the instructor feels it is time to bring closure to the question by having students offer up their solutions and their justifications. The instructors are careful not to wrap up a question too quickly so that students have sufficient opportunities to verify conjectures made by other students and to build a stronger learning community among the students. At the conclusion of a problem, students are asked to reflect back upon the problem, paying careful attention to the strategies utilized and the mathematics, and the instructor verifies that all student questions have been answered (Lubinski & Otto, 2004)

Students tend to be intimidated by this course, and thus, often try to persuade course instructors to provide more information for solving the problems or show them examples. However, they soon realize that this will not happen, so they persevere along with their classmates to progress through the problems. After five semesters of teaching the course, the researchers conducted a study to gauge the preservice teachers' beliefs regarding how mathematics should be taught and learned. A 5-question written survey was constructed and administered to the preservice teachers at the beginning of the course and then again at the conclusion of the semester. The questions asked students to discuss their beliefs and attitudes towards understanding and doing mathematics as well as their past experiences involving math. Furthermore, the researchers individually interviewed each preservice teacher at the end of the semester to discuss their pre- and post-survey responses and to question them regarding their grades in mathematics, advice they would give to high school teachers preparing students for college, and the impact this course will have on their classrooms. Findings from the surveys and interviews indicate that the course has positively influenced the preservice teachers' attitudes and beliefs regarding mathematics. The majority of the students are no longer satisfied to simply memorize mathematics, instead preferring to have conceptual understanding. They also wished that the focus on conceptual understanding began earlier in their educational careers. Students also indicated that they appreciated being able to work problems in a variety of ways and realized that math was not as frustrating when they were allowed to solve problems in their own ways. Lastly, students felt as though they were not alone in their struggles and that the learning community that developed among the students in the class led to increased self-confidence in understanding mathematics (Lubinski & Otto, 2004).

Thanheiser, Browning, Moss, Watanabe, and Garza-Kling (2010) developed a framework of design principles to reshape the way mathematics content courses for preservice teachers were taught. This framework was based on the authors' desire to build upon students' current conceptions and to model practices consistent with the recommendations in the National Council of Teachers of Mathematics *Principles and Standards for School Mathematics* (2000), which focus on students developing a deep understanding of mathematics. By having the preservice teachers experience a course such as this, it is the hope of the instructors that the students will model a similar instructional style when they begin teaching. The framework proposed in the research consists of three principles. The first principle is that students' currently held beliefs form the basis of mathematical ideas. The second principle of the framework is that mathematics courses specifically designed for preservice teachers should be based on a model that encourages teaching for understanding. The third and final principle is that connections should be developed between mathematical content knowledge and pedagogical content knowledge, children's thinking, and explaining curriculum decisions (Thanheiser et al., 2010).

Several examples are provided that illustrate how the framework is used in a variety of different mathematical areas, including angles, the unit whole, and area. However, one example that focused on place value will be discussed further to illustrate how the framework applies. The goal of the lesson was to help the students develop an understanding of multi-digit whole numbers. The authors realized that many students had a misconception regarding the interpretation of digits in multi-digit numbers, with many viewing the digits in terms of ones instead of in terms of their value such as tens or hundreds. Tasks were developed to help students see the connections between the digits and their place value, with one task in particular using digit cards to build particular numbers and perform operations upon them. The next part of the task focused on students performing addition of two 3-digit numbers using the digit cards. Because it was important for the researchers to teach their classes in the same way they would like for the preservice teachers to teach their classes, the students were encouraged to work independently first to come up with their own algorithm before discussing their thought processes in small groups. By working in this manner, students are constructing their own knowledge of how and why their particular algorithm works. Later in the task, the preservice teachers were able to connect the mathematical content knowledge from their class to how elementary children are learning that same topic by watching videos of young children working on similar addition problems. By completing this task, students were able to better develop the mathematical content knowledge of place value and addition, specialized content knowledge of using the digit cards to perform addition, and their pedagogical content knowledge through the discussion of how children think and learn about addition (Thanheiser et al., 2010).

There is no doubt that it is impossible to teach preservice teachers everything they will need to know in their future teaching. Thus, the researchers hope that courses designed using their framework will produce independent, reflective learners who are able to tackle new content and pedagogies as they come across them, and most importantly, make sense of them. They advise that adequate time be provided for preservice teachers to explore quality problems in depth while utilizing a variety of representations and communicating their thought processes. Because there is no agreement among teacher educators as to the specific content that should be covered in courses such as these, the focus should then shift to *how* the mathematics should be taught to best serve the students. It is the authors' belief that they best way to achieve this is through a course that encourages deep conceptual understanding, promotes specialized content knowledge, and highlights the connections between content knowledge and children's thinking and the elementary curriculum (Thanheiser et al., 2010).

Math Anxiety

Math anxiety can be defined as being a state of discomfort that one experiences when involved in situations requiring the use of mathematics and can affect people of all ages - from elementary school children to adults (Ashcraft, 1995; Cemen, 1987; Wu, 2014). Many who suffer from math anxiety perceive mathematical tasks as being threatening to their self esteems and may also experience physical changes such as tension, sweaty palms, difficulty breathing, and inability to concentrate (Burns,1998; Bursal & Paznokas, 2006; Dutton & Dutton, 1991; Hembree, 1990; Trujillo & Hadfield, 1999). Research has shown that the anxiety levels of early childhood education majors are comparable to students enrolled in developmental math courses, whereas preservice elementary education teachers have been shown to have greater levels of math anxiety and less confidence in their ability to learn mathematics than those students pursing other college degrees (Bursal & Paznokas, 2006; Hembree, 1990; Perry 2011; Vinson, 2001; Zientek et al., 2010). This could be detrimental to their future students considering that it is possible for math-anxious teachers to inadvertently pass their anxiety and negative attitudes regarding mathematics on to their students (Buhlman & Young, 1982; Karp, 1988, 1991; Middleton & Spanias, 1999; Scholfield, 1981). Math-anxious teachers also have a tendency to teach in the same manner in which they had been taught, employing traditional lecture-style methods that are inconsistent with the NCTM recommendations for mathematics education, which emphasize conceptual understanding through problem solving and cooperative learning (Bush, 1981; National Council of Teachers of Mathematics, 2000, 2014; Wilkins, 2002).

Causes of Math Anxiety

The causes of math anxiety in preservice elementary teachers were revealed in several studies through in-depth student interviews. Harper and Daane (1998) selected 11 preservice elementary teachers to participate in individual interviews with the researchers to discuss their own personal experiences that led to their math anxiety. These students were selected because they exhibited the greatest differences in their scores on the Mathematics Anxiety Rating Scale (MARS) prior to and after completion of a mathematics methods course. The MARS consists of 98 Likert-scale items and is used to measure mathematics anxiety in a variety of situations. Four common themes leading to the students' math anxiety emerged from the interviews: (a) math content, (b) teacher instruction and attitude, (c) specific episodes in math class, and (d) aspects not related to the math classroom. Students stressed that problem solving and word problems caused them to feel anxious. Also, anxiety began as early as elementary school for the students when they were introduced to multiplication and long division. However, anxiety levels increased as students became older and entered high school, particularly when they were enrolled in a geometry course. Students also contributed the onset of their anxiety to math classes being boring, time-consuming, taught too quickly, having to complete timed tests, and having too much emphasis placed on obtaining the correct answer. Math-anxious students also described being embarrassed in class for giving an incorrect answer or being made to feel dumb when they asked questions or were not able to correctly solve a math problem. Some students even attributed their math anxiety to having little or no confidence in their mathematical ability, possessing a general slowness for learning, and pressure from their parents to succeed in mathematics.

Many of the findings of Harper and Daane (1998) were later replicated in studies by Trujillo and Hadfield (1999), Sloan (2010), and Swars et al. (2006). In the aforementioned studies, students who participated in the interviews were selected because of the high levels of math anxiety they displayed after completing the MARS.

Trujillo and Hadfield (1999) interviewed five preservice teachers and found that although the students experienced some levels of math anxiety due to negative school experiences in elementary school, the anxiety increased dramatically upon entering junior high and high school. Interviewed students also stated that their anxiety was most prevalent during timed mathematics activities, especially tests. Also, none of the five preservice teachers felt as though they had any parental support regarding mathematics at home. In a study conducted by Sloan (2010), 12 preservice teachers were interviewed regarding factors that contributed to their feelings of anxiety towards mathematics. Not only were negative school experiences, parental influences, and teaching practices in the classroom found to contribute to math anxiety, additional contributing factors were found. These include "low math achievement, test anxiety, lack of confidence, negative attitudes, [and] mathematics avoidance" (Sloan, 2010, p. 250). Also, the majority of interviewed students believed that their math anxiety began because of experiences they had while in high school. Swars et al. (2006) confirmed that preservice teachers exhibiting high levels of math anxiety do so because of prior negative school experiences in mathematics. Experiences involving memorization of procedural knowledge in mathematics instead of an understanding of conceptual knowledge are common among those math-anxious students who were interviewed.

Preservice elementary teachers with particular learning styles have been shown to be likely to have high levels of math anxiety. A study by Ertekin, Dilmac, and Yazici (2009) investigated the relationship between the math anxiety levels of preservice elementary teachers and their learning styles. A sample of 293 preservice teachers was given a multiple choice questionnaire to gauge their levels of math anxiety and the

Marmara Learning Styles Scale to determine the students' learning styles. It was found that students with an authority-based learning style, which is characterized by needing the assistance of experts in their studies, were more likely to experience anxiety regarding mathematics testing and evaluation and mathematics anxiety in daily life than students of other learning styles. On the other hand, tactile learners tended to have less mathematics anxiety in testing and daily life. Visual and tactile learners were also found to experience more anxiety regarding mathematics lessons than students of other learning styles. The authors believe that the results of their study support the claim that math anxiety can be brought on due to a mismatch between a student's learning style and the instructor's teaching style. A study by Perry (2011) suggests similar findings in that students can experience math anxiety because of the mismatch between their own personal mastery goals and the instructors' performance-oriented goals, which are typical of a traditional mathematics classroom.

Other studies have suggested even more possible causes of math anxiety, as well as other characteristics of math-anxious students. In a study by Brady and Bowd (2005), 238 preservice elementary teachers were administered a questionnaire regarding their mathematics education as well as the MARS. The MARS scores of the female students were significantly higher than that of the male students. Also, a negative relationship was found between the respondents' MARS scores and their highest level of formal mathematics instruction. It was also determined that students who stated their least favorite subject was mathematics were more likely to have higher MARS scores than those who enjoyed the subject. Another study reported that some preservice teachers exhibited increased levels of math anxiety when asked to use manipulatives to demonstrate mathematical concepts. The reason for this anxiety stemmed from the fact that the students had no prior experience with the manipulatives (Vinson, 2001). Preservice teachers are also more likely to experience math anxiety in their mathematics methods courses when the instructor is either new to the college or new to teaching the methods course (Gresham, 2007; Vinson, 2001).

Consequences of Math Anxiety

The occurrence of math anxiety in preservice elementary teachers has been shown to have a negative impact on their self-confidence in learning and teaching mathematics. In a study by Bursal and Paznokas (2006), 65 preservice elementary teachers completed the Revised Mathematics Anxiety Survey (R-MANX) and the Mathematics Teaching Efficacy Belief Instrument (MTEBI). The MTEBI is a 21-item instrument designed to address teacher efficacy. Students were grouped into 3 categories based upon their reported levels of math anxiety: (a) low math anxiety, (b) moderate math anxiety, and (c) high math anxiety. When the students' responses on the MTEBI were compared based on anxiety group, those students with high math anxiety tended to have the lowest confidence levels. For example, 95% of students in the low math anxiety group felt they would be able to teach math effectively whereas only 48% of students in the high math anxiety group did. Also, 90% of students in the low math anxiety group knew procedures to effectively teach mathematics whereas only 52% in the high math anxiety group did. Overall, it was found that a significant difference did exist between the mean scores of the low math anxiety group and the high math anxiety group for all nine items on the MTEBI.

Swars et al. (2006) surveyed 28 elementary preservice teachers enrolled in a mathematics methods course. Participants completed both the MARS and the MTEBI. Correlations were computed, and it was found that a significant moderate negative relationship ($r = -.46$) existed between the students' levels of math anxiety and their mathematics teacher efficacy, meaning that students with higher levels of math anxiety had less confidence in their skills and abilities to be effective math teachers. Similar results were also found by Brady and Bowd (2005). Although the MTEBI was not administered to gauge the students' beliefs regarding their capabilities as math teachers, students completed the MARS and were asked to rank their level of confidence in teaching mathematics following a six-week teaching practicum and their level of enjoyment of mathematics. A negative correlation was found between the students' MARS scores and their confidence to teach mathematics. Those students who exhibited high levels of math anxiety had less confidence in their ability to teach mathematics during the practicum than those students who had low math anxiety. It was also found that students who enjoyed mathematics in elementary and secondary school were more likely to have confidence in their ability to teach math.

Liu (2008) investigated preservice elementary teachers' anxiety towards teaching mathematics through the use of online discussions. In his study of 39 preservice teachers enrolled in a mathematics methods course, students participated in an eight-week pre-student-teaching practicum. Students completed a 15-item questionnaire called the Anxiety Towards Teaching Mathematics Questionnaire (ATTMQ), which had been developed by the researcher. Students completed the ATTMQ prior to the practicum and then again at the end of the practicum to assess whether or not their anxiety towards teaching mathematics had changed. During the time of the practicum, students also participated in weekly online discussions based upon topics provided by the instructor. Online discussion topics focused on anxiety towards teaching math, the perception that math is more difficult than other subjects, the emphasis on understanding mathematical concepts versus memorizing math facts, and how not to pass math anxiety on to young students. When the pretest and posttest scores of the ATTMQ were compared, nearly 80% of the students had a lower posttest score whereas only 18% had a higher posttest score. Also, there were significant differences found between the pretest and posttest ATTMQ scores for three constructs: (a) anxiety caused by the belief that math is more difficult than other subjects, (b) anxiety caused by other peoples' perceptions of one's teaching math, and (c) anxiety caused by teaching in general. The author attributes the reduction in the students' anxiety towards teaching math to their participation in the online discussion; however, the reduction in anxiety levels could have also been partly attributed to the students' participation in the pre-student teaching practicum.

Perry (2011) focused on preservice elementary teachers' achievement goals in relation to their attitudes towards mathematics. The 340 participants in the study were students enrolled in mathematics for teachers courses from four different universities. The students completed a questionnaire designed to assess their achievement goal orientation as well as their attitudes towards mathematics. The results showed that the majority of these preservice teachers had an orientation to mastery goals, meaning that their primary goal is to gain competence in actually learning and understanding the course content. Also, there was a significant positive relationship found between having mastery goal orientation and confidence in learning mathematics. However, math content courses are typically taught in a traditional lecture format, which is not conducive to the goal orientation of the many preservice teachers. The author suggests that this mismatch between the goals of the mastery-oriented student and the performance-oriented classroom may result in lower confidence levels in learning mathematics and increased levels of math anxiety. However, Alsup (2004) found that the confidence levels regarding the teaching of mathematics for those students who are enrolled in traditional lecture-style mathematics courses were not statistically different from those of students who are enrolled in constructivist-style mathematics courses. Alsup also found that a significant difference existed between the autonomy levels of those students who participated in the experimental constructivist-style courses versus those in the traditional lecture-style course. Students in the experimental courses had more confidence in their mathematical abilities at the conclusion of the course than those students in the lecture-style course.

Studies have also found that math anxiety and achievement are negatively correlated, however, these studies do not focus solely on participants who are preservice elementary teachers. (Ashcraft, 1995; Ashcraft & Krause, 2007; Wu et al., 2014). Ashcraft and Krause (2007) report that when a person's math anxiety sets in, then his working memory becomes drained. Furthermore, in a study of 80 undergraduate students, the researchers found that math-anxious students tended to have lower achievement as the difficulty of the math increased from simple numeric computations to more complex math typically taught in upper elementary grades (Ashcraft & Krause, 2007). Wu (2014) also researched the relationship between mathematics achievement and mathematics anxiety, but this time the participants were elementary children. He also found that higher levels of math anxiety resulted in lower levels of achievement. Another effect of math anxiety on students' achievement is that they tend to work quickly on assessments, thus sacrificing accuracy, resulting in lower test scores (Faust et al., 1996). This research indicates that there is a need in the literature to address mathematics achievement specifically regarding preservice elementary teachers.

Reducing Math Anxiety

The majority of research involving strategies to reduce math anxiety among preservice elementary teachers focuses on students enrolled in a mathematics methods course. Harper and Daane (1998) conducted a study in which 53 preservice elementary teachers were enrolled in a methods course focusing on class discussions of readings and evaluation measures, whole group and small group work, using manipulatives, and field experiences. Participants completed two instruments to assess their levels of math anxiety and factors affecting it. The 98-question MARS was administered at the beginning of the semester and then later after the completion of the methods course. A 7-item questionnaire called the Methods Course Reflection (MCR) was administered at the conclusion of the semester to determine which factors in the methods course influenced the anxiety levels. Eleven students who displayed the greatest differences between their MARS scores then participated in individual interviews with the researchers. At the conclusion of the semester, it was found that a significant difference existed between the students' pretest MARS scores at the beginning of the semester and their posttest MARS scores at the end of the semester. Approximately 83% of the students experienced a decrease in math anxiety, whereas 17% experienced an increase. The results of the MCR showed that 60% of students reported that working with partners, in cooperative learning groups, and in centers decreased their levels of math anxiety. The students also felt that working with manipulatives, writing in journals about mathematics, and participating in fieldwork at a local elementary school contributed to a reduction in their math anxiety. However, only 41% of the students reported on the MCR that completing problem solving activities in class reduced their levels of math anxiety, whereas 59% of the students reported that there was either no change or an increase in their math anxiety. The student interviews revealed other factors contributing to lowered math anxiety levels. These factors include having instructors talk to the students instead of lecturing them, actively participating in the class with manipulatives instead of taking notes, and being encouraged to work problems in more than one way.

Findings similar to those of Harper and Daane (1998) were reported by Gresham (2007) and Vinson (2001). In Gresham's study of 246 early childhood and elementary preservice teachers over a period of six semesters, posttest MARS scores after the completion of a mathematics methods course were significantly lower than pretest MARS scores for five of the six semesters. Students reported through interviews, discussions, and journal entries the factors they felt attributed most to their decreased levels of math anxiety. An overwhelming majority of students felt that the methodology of the course with its emphasis on using manipulatives to be the primary factor. Other factors included the instructor's personality and enthusiasm for teaching, the inviting classroom atmosphere, and writing in journals. Vinson's study focused primarily on whether or not math anxiety levels would be reduced after preservice teachers completed a methods course focusing on the use of manipulatives. Eighty-seven students over the course of four quarters completed the MARS prior to and after completion of the methods course. Overall, the group means for the pretest and posttests MARS scores were significantly different, indicating a reduction in math anxiety. However, when the pretest and posttest MARS scores were compared by quarter, the results showed that the students' anxiety levels were not reduced as much during the fall quarter as they were during the winter, spring, and summer quarters. One possible reason the reduction in math anxiety during the fall quarter was less than the others could be that it was the instructor's first semester at the college and also her first time teaching a mathematics methods course.

A study by Sloan (2010) had results similar to those of Gresham (2007). Seventy-two preservice elementary teachers enrolled in a standards-based mathematics methods course participated in the study. The course philosophy was based on the National Council of Teachers of Mathematics *Principles and Standards for School Mathematics* (2000). Students enrolled in the course modeled mathematical concepts using manipulatives, were responsible for teaching lessons to their peers using manipulatives, and participated in field experiences in local elementary schools. The MARS was administered at the beginning of the semester and also at the conclusion of the semester to determine if the students experienced a decrease in math anxiety as a result of completing the course. Results showed a significant difference between pretest and posttest MARS scores, indicating that participation in the course was effective in reducing math anxiety. Twelve students with the greatest differences between their MARS scores participated in interviews to assess which factors were most beneficial in reducing their math anxiety. Most of the students reported that the course methodology, field experiences, peer teaching, instructor's disposition, and classroom atmosphere were effective in reducing their levels of math anxiety. However, several students reported that the course methodology, as well as the course tests, may have caused their math anxiety levels to increase.

Alsup (2004) sampled 61 preservice elementary teachers enrolled in mathematics content courses for teachers instead of mathematics methods courses for his study to determine the effects of a constructivist learning environment on math anxiety. Two experimental classes were taught using a constructivist model in which student thinking and active learning were encouraged. These two classes consisted of two different courses in the required course sequence for preservice teachers. One course was a control class and was taught in a traditional lecture-style format. The students completed an abbreviated version of the MARS at the beginning and the end of the semester. The researcher hypothesized that students enrolled in the experimental courses would experience a greater decrease in math anxiety at the conclusion of the course than students in the control course. Although the results were not statistically significant, the students enrolled in the lecture-style control class showed the largest decline in levels of math anxiety. However, when the pretest and posttest anxiety scores for the students from the three classes are analyzed collectively, a significant decrease in math anxiety scores was found.

Summary

The research surrounding math anxiety among preservice elementary teachers appears to be fairly consistent in regard to the possible causes of the anxiety, the impact on the students' confidence levels related to the learning and teaching of mathematics, and the methods used to reduce the anxiety. Although it appears that the onset of math anxiety in many students occurs prior to students entering college, there are several methods that can be employed in order to alleviate the students' anxiety. The use of manipulatives, working with partners or in small groups, having students actively participate during the classes, and writing in journals about mathematics are all methods that decreased anxiety levels for many students and can easily be incorporated into any math content course for teachers and math methods course. Two studies reported increased levels of math anxiety when the course instructor was new to either the university or new to teaching the methods course.

The majority of research in this area focuses on students enrolled in mathematics methods courses. Preservice teachers are typically required to complete a minimum of two to four mathematics content courses for teachers along with a minimum of one methods course. For students with moderate to severe math anxiety, intervention strategies should be implemented prior to the methods course in order to have the greatest effect on reducing anxiety levels. More research is needed to determine if the methods that are successful in reducing anxiety levels in methods courses are also successful in reducing anxiety levels in mathematics content courses for preservice teachers.

In nearly all of the studies, at least some preservice teachers who participated experienced an increase in math anxiety. Because every student is unique, interventions will not be successful in reducing math anxiety for all participants. However, interventions that result in reduced anxiety levels for the majority of participants should be considered for implementation in math methods and content courses. Considering that preservice teachers are both students of mathematics and future teachers of mathematics, these teacher candidates may be the link to break the cycle of math anxiety being passed from teacher to student.

When one considers the causes of math anxiety and the methods that have been shown to reduce it, it appears that instructional strategies often found in constructivist, inquiry-based classrooms may be beneficial in lowering the math anxiety levels of preservice elementary teachers. Also, the recommendations from the CBMS, which promote specialized mathematics courses focused on higher-order thinking, problem-solving, and communication, are more aligned to constructivist learning theory and inquiry than they are to behaviorist learning theory and traditional teaching methods. With the Common Core State Standards for Mathematics currently being implemented in elementary schools across the nation, it is of the utmost importance that preservice teachers are adequately trained to be effective, knowledgeable teachers in the classroom. If elementary teachers will be expected to teach to such high standards in mathematics, it only makes sense that they are also held to comparable high standards in their mathematics content courses. The CBMS has provided those with the responsibility of educating future mathematics teachers with minimum guidelines for quality programs and coursework to ensure teachers that are prepared to enter the workforce. Research presented has shown several nontraditional methods of conducting mathematics courses that are proving to be effective in changing preservice teachers' beliefs, attitudes, and most importantly, understanding of mathematics. A student's success and confidence in mathematics begins with the foundation he receives in elementary school. In order for all students to get started on the right foot, it begins with properly training elementary teachers for the challenges that lie ahead of them in the classroom.

Justification

The content presented in this literature review describes two common learning theories, behaviorist learning theory and constructivism; common instructional strategies in the higher education mathematics classroom; professional recommendations for mathematics courses specifically designed for preservice elementary teachers; and math anxiety. The research discussed provides evidence of the effectiveness of IBL in higher education courses in developing deep understanding of course content and the habits of mind of mathematicians. Furthermore, characteristics and goals of IBL courses are aligned to the suggestions as to what is needed in courses for preservice teachers as well as reducing math anxiety.

Only one published study sought to examine the relationship between preservice teachers' math anxiety and instructional strategy. However, Alsup's (2004) study was strictly quantitative in nature, and there was only one control class in which traditional teaching methods were employed. The two experimental classes that incorporated constructivist ideas were entirely different courses – one of which was the same as the control class, and one that had no corresponding control class. Thus, it is reasonable to assume that the lack of significant results regarding math anxiety could be attributed to the differing course content between the control and experimental groups. The researcher believes that a mixed methods research approach may yield different results than the Alsup (2004) study. In addition to collecting and analyzing data regarding students' anxiety level, rich data from students' journals and focus groups will also be collected and analyzed to help to obtain a more comprehensive picture of how instructional strategies affect preservice teachers' levels of math anxiety.

CHAPTER III - METHODOLOGY

Introduction

This chapter includes a description of the research methods and procedures that were used in this study for the collection and analysis of the data to determine the effects instructional strategies in a mathematics content course have on preservice elementary teachers' levels of math anxiety and achievement. Included in this chapter are descriptions of the participants, instruments, research design, and data analysis methods.

Research Questions

The following questions were investigated in this research study.

1. As measured by the Mathematics Anxiety Scale Short Version (MARS-S), what effect do different instructional strategies have on preservice teachers' levels of math anxiety?

2. As measured by pre- and post-tests of preservice teachers' mathematical content knowledge, what effect do different instructional strategies have on preservice teachers' mathematics achievement?

3. How do preservice teachers describe their experiences in Math 277 in regard to their math anxiety and mathematics achievement?

Research Hypotheses

Research questions 1 and 2 were investigated through statistical data analysis of the following research hypotheses.

Research Hypothesis 1: The preservice teachers who are enrolled in the courses with IBL as the instructional strategy will experience a significant decrease in their levels of math anxiety as compared to the preservice teachers who are enrolled in the courses with traditional teaching methods as the instructional strategy.

Research Hypotheses 2: The preservice teachers who are enrolled in the courses with IBL as the instructional strategy will experience a significant increase in their achievement levels as compared to the preservice teachers who are enrolled in the courses with traditional teaching methods as the instructional strategy.

Participants

Participants for this study included 103 preservice elementary teachers who were enrolled in the researcher's Math 277 course at Southeastern Louisiana University in the Fall 2015 semester. Approximately 96% of the participants were female, 2% freshmen, 36% sophomores, 53% juniors, and 9% seniors. All participants were at least 18 years of age. Each of the participants were majoring in education with a concentration in either early childhood (grades PK-3), elementary (grades 1-5), middle school (grades 4-8), or special education (grades K-8). There were four sections of the class being offered with enrollment totals in each class of 30, 28, 32, and 13 students.

Course Design

There were four sections of Math 277 offered in the Fall 2015 semester and taught by the researcher. Two sections met on Mondays and Wednesdays each week, whereas the other two met on Tuesdays and Thursdays. Each class met for a total of 2.5 hours each week. Because the Monday/Wednesday classes and Tuesday/Thursday classes each met back-to-back in the same classroom, the same instructional strategy was used in the Monday/Wednesday classes and the other instructional strategy was used in the Tuesday/Thursday classes. This was to keep the classes with differing instructional strategies as separate as possible. The Monday/Wednesday classes were randomly chosen to be the sections in which traditional teaching methods were used. Thus, the Tuesday/Thursday sections were taught using IBL.

On the first day of class, the researcher described the study to the participants and collected consent forms. To preserve their anonymity throughout the study, all students selected a randomly-generated 6-digit course ID number that they used throughout the semester. Students were required to use their course ID number on all instruments in place of their name. The lists of student names and corresponding course ID numbers were kept in an administrative assistant's desk until it was time to submit student grades at the end of the semester. At that time the researcher obtained access to the list. Because the inquiry approach was a new experience to most students enrolled in the IBL sections, a detailed description of the format of the class and expectations of the students were also provided on the first day. In all classes, the participants who elected to participate in the study completed the initial questionnaire and Mathematics Anxiety Rating Scale Short Version (MARS-S) to assess their math anxiety levels prior to the intervention. On the second day of class, students in each of the classes completed the content knowledge test that addressed Math 277 course topics. This provided a baseline score of the participants' knowledge prior to the intervention.

During the next 14 weeks of the semester, the classes were conducted using methods and techniques typical of IBL and traditional teaching. During that time, participants periodically completed journal entries that were collected in class. One week before the final exam, the follow-up questionnaire and MARS-S were administered and focus groups conducted during scheduled class times. In order to encourage participants to speak openly regarding their experiences over the course of the semester, the researcher did not conduct the focus group sessions. Instead, two colleagues experienced with qualitative research and IBL led the focus groups and provided an audio recording of the sessions to the researcher after final course grades had been submitted. The students' final exam consisted of the same questions from the initial content knowledge test in addition to several free response questions. The scores from this post-test of content knowledge were used to determine any changes in the participants' achievement.

The same basic format was followed for the IBL classes. At the beginning of the semester, students were provided a problem set consisting of over 350 problems organized by topic and relating to the study of fractions, decimals, probability, and data analysis in the elementary and middle-school curriculum. Course discussions, assignments, and assessments were influenced by the content within the problem set. A typical class meeting began with students signing up to present selected problems from the course problem set. These problems were announced during the previous class meeting so that students would have sufficient time to complete them and any others from the assigned section in the problem set. If multiple students volunteered to present a problem, then one student was randomly selected as the presenter. Students were also given the opportunity to list any other problems that they would like to discuss in class, and volunteers were selected to present those problems. The majority of class time was allocated to student presentations and questions. After all presentations for the day had been completed, students began working on the next assigned section from the course problem set. The next class meeting's presentation problems were listed on the white board at the end of each class. Small group work and communication with peers were emphasized during this time. Because the focus in the IBL classes was for the students to develop deep conceptual understanding as well as effective classroom communication and problem-solving skills, the instructor did not conduct any lectures. This was to minimize the likelihood of students' mimicking the instructor's work, thus promoting independence in the students' thinking.

The classes that were taught using traditional teaching methods were teacher-centered classes with the majority of class time spent on the instructor's lectures with little time allocated for independent problem solving and communication among the students. Classes began with the instructor spending a brief amount of time answering the students' homework questions before new material was presented entirely by the instructor. Any questions from the students that arose during class time were answered by the instructor. The basis of the instructor's lectures and the assigned homework problems were from the IBL course problem set. Thus, the students in the IBL and traditional classes completed the same problems over the course of the semester although the manner in which those problems were presented differed.

At the time of the study, the researcher had eight years of mathematics teaching experience and six years of teaching experience in Math 277 and its predecessor (formerly Math 267). The researcher had previously taught the course using traditional teaching methods for two years before adopting a flipped classroom teaching method for three years. After attending a weeklong workshop on teaching using IBL in college mathematics classes, the researcher began teaching the course using IBL techniques the year preceding this study.

Instrumentation

A variety of instruments were used to collect data for the study. Data were collected through initial and follow-up questionnaires, the MARS-S, a content knowledge assessment, participants' journal entries, and end-of-semester focus groups.

Math Anxiety

To determine the participants' levels of math anxiety, the Math Anxiety Rating Scale Short Version (MARS-S) was administered pre- and post-intervention. A copy of the instrument is located in Appendix A. The researcher obtained copies of the MARS-S from the creator of the instrument, Richard Suinn (2003). A copy of email correspondence showing permission to use the instrument is located in Appendix B. The MARS-S is a 30-item self-rating scale that uses a 5-point rating scale for each of the 30 items with a score of 1 indicating that the respondent is not at all frightened by that situation and a score of 5 indicating that the respondent is very much frightened by that situation. Anxiety levels are determined by adding the respondents' raw scores on each item. The minimum score for the instrument is 30, and the maximum score is 150. The MARS-S has a reliability coefficient of 0.90 ($p < .001$) based on college students' scores who were retested one week after initially completing the MARS-S. Cronbach's alpha, a measure of internal consistency reliability, is .96, which confirms the instrument has high internal reliability and that the items are assumed to be measuring the same construct, presumably, math anxiety. The MARS-S has also demonstrated both construct and content validity. Correlations between the MARS-S and the longer 98-item MARS were found to be $r = .92$ ($p < .001$) and $r = .94$ ($p < .001$) for both tests when they were administered one week apart. Furthermore, MARS-S scores are negatively correlated with mathematics grades ($r = -.41$ ($p < .001$), which is not surprising because math anxiety negatively influences math performance. The results of a factor analysis of MARS-S data indicate that there are two primary factors: (a) learning mathematics anxiety and (b) mathematics evaluation anxiety (Suinn, 2003). Another study by Baloglu (2010) showed that the MARS-S measures the construct of math anxiety because the total MARS-S score positively correlates with each of the following five factors measured on the instrument: (a) computation anxiety, (b) mathematics test anxiety, (c) application anxiety, (d) course anxiety, and (e) social anxiety.

Content Knowledge

To assess participants' content knowledge and measure their achievement over the course of the semester, the researcher had participants complete a 20-question multiple-choice assessment covering course topics (Appendix C). The exact same questions were asked at the beginning of the semester and then again at the end of the semester on the final exam. With 16 weeks between the initial assessment and the participants having no knowledge that the same assessment was to be given again at the conclusion of the semester, the likelihood of practice effects skewing the data should be minimal. Two instructors at Southeastern Louisiana University who regularly taught Math 277 reviewed the assessment and confirmed that the content was valid for the course.

Other Instruments

Initial and follow-up questionnaires (Appendices D and E, respectively) designed by the researcher were administered in order to collect demographic data and data regarding the participants' previous math experiences, their opinions and reflections on the course, and their math anxiety. Preliminary focus group questions are provided in Appendix F and were administered during the scheduled class time during the last week of classes. Although these questions served as a starting point for the focus groups, additional questions were asked based upon participants' responses. Two colleagues of the researcher who had qualitative research experience and were familiar with IBL led the focus groups so that participants were more likely to be honest in their responses without fear of having their grades suffer based upon their responses.   Each of the four focus group sessions were audio recorded, and the researcher did not receive the recordings until after final grades for the semester had been submitted. Throughout the semester, students were expected to complete regular journal entries in which they reflected upon their experiences, understanding of course material, and anxieties. In order to minimize the chance of the instructor identifying students course ID numbers based on their seating assignments, journal entries were collected in class by having all students pass their papers to a designated student who would then shuffle the papers before handing them to the instructor. Appendix G lists the journal prompts that were assigned to students.

In order to encourage participation by the majority of students, participants received a grade for completing MARS-S, initial and follow-up questionnaires, and journal entries. Although all data collected remained confidential, anonymity could not be granted because the post-assessment for content knowledge was a subset of the students' final exam and affected the students' overall course grades.

Research Design

The research design for this study was a mixed methods embedded design. The primary component was quantitative in nature and representative of a quasi-experimental nonequivalent control group design because the researcher was unable to assign individuals to the control and experimental groups. Instead, the groups were selected at random to receive different instructional strategies. The control group was the classes that received traditional mathematics instruction, whereas the experimental group was those who were in the IBL classes. The instructional strategy, either traditional or IBL, represented the independent variable. The two dependent variables were the participants' math anxiety and achievement.

The secondary component of the research design was phenomenological in nature. Qualitative data were collected at several points throughout the study through open-ended questions on the initial and follow-up questionnaires, student journal entries, and end-of-semester focus groups. Figure 1 illustrates the research design for the study.

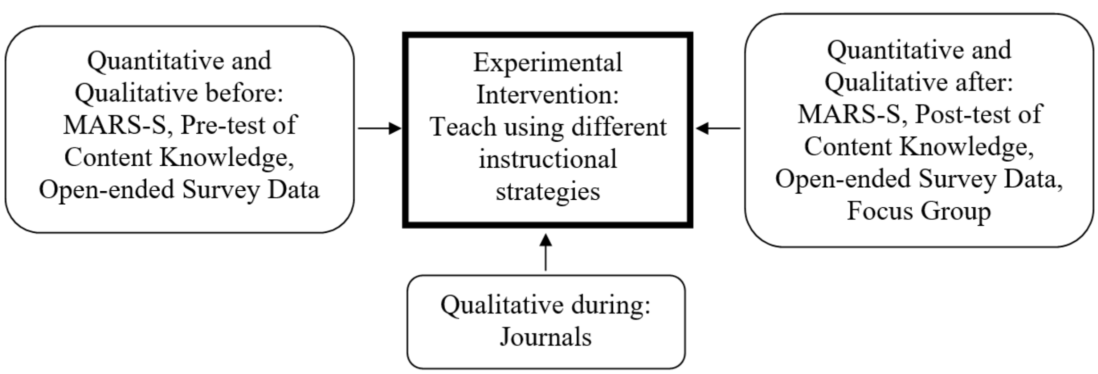


Figure 1. Research design

Data Analysis

All quantitative data analysis was conducted using SPSS statistical software. Summary statistics for all demographic data, MARS-S scores, and content knowledge scores were computed. Two-way repeated measures ANOVA and t-tests were conducted to determine if there were significant differences in math anxiety or achievement between the two groups based on instructional strategy. Correlational analysis between math anxiety and achievement was conducted to determine if a relationship exists between the variables. Independent samples t-tests were also performed on the responses to students' experiences and preferences in mathematics classes to determine if differences existed between the group. Thematic analysis was performed on the qualitative data from journal entries to find meaning in the preservice teachers' experiences in the class.

CHAPTER IV – RESULTS

Summary

This study considered how different instructional strategies affected preservice elementary teachers' levels of math anxiety and their achievement in a math content course while considering descriptions of their experiences in the course in relation to their math anxiety and achievement. IRB approval was granted at The University of Southern Mississippi and Southeastern Louisiana University prior to the start of the semester and data collection. Appendix H contains the IRB approval letters. Participants' levels of math anxiety were assessed using the Math Anxiety Rating Scale Short Version (MARS-S) pre- and post-intervention and through self-reports in journal entries throughout the semester. The MARS-S is a 30-item self-rating scale created by Richard Suinn (2003) that uses a 5-point rating scale for each of the 30 items with a score of 1 indicating that the respondent is not at all frightened by that situation and a score of 5 indicating that the respondent is very much frightened by that situation. Anxiety levels are determined by adding the respondents' raw scores on each item. To assess participants' content knowledge and measure their achievement over the course of the semester, the participants completed a 20-question multiple-choice, researcher-created content knowledge assessment at the beginning of the semester and at the end of the semester on the final exam. One question on the content knowledge assessment contained a typographical error on the initial assessment, so the responses from that question were omitted on both the initial and follow-up assessments in the analysis. Researcher-designed initial and follow-up questionnaires were administered to collect demographic data and data regarding the participants' previous math experiences, their opinions and reflections on the course, and their math anxiety. Focus groups in each of the classes were administered during the scheduled class time during the last week of classes. The moderator of the focus groups in the traditional classes did not follow protocol for either focus group; thus, the data from the focus groups were considered invalid and not used in the analysis. Throughout the semester, students completed several journal entries where they reflected upon and rated their understanding of course material and math anxiety on a scale from 1 to 10. A score of one indicated a low level of understanding (or math anxiety), whereas a score of 10 indicated a high level of understanding (or math anxiety). The researcher defined three levels for understanding and math anxiety based on participants' scores: (a) low levels have scores between 1 and 3, inclusive; (b) moderate levels have scores between 4 and 7, inclusive; and (c) high levels have scores between 8 and 10, inclusive.

The three research questions were considered when reviewing and analyzing the data.

1. As measured by the Mathematics Anxiety Scale Short Version (MARS-S), what effect do different instructional strategies have on preservice teachers' levels of math anxiety?

2. As measured by pre- and post-tests of preservice teachers' mathematical content knowledge, what effect do different instructional strategies have on preservice teachers' mathematics achievement?

3. How do preservice teachers describe their experiences in Math 277 in regard to their math anxiety and mathematics achievement?

Quantitative Data Analysis

Descriptive statistics were obtained and quantitative data analysis performed using SPSS statistical software. Summary statistics of the demographic data and the results of the analysis are presented.

Demographic Data

Demographic data were collected from all participants in the initial questionnaire. These data include the participant's class standing, GPA, college major, grade in the previous math course, number of IBL classes previously taken, and whether or not the participant enjoys mathematics classes. Of the 103 participants, 43.7% were enrolled in one of the IBL classes while 56.3% were enrolled in one of the traditional classes. In the IBL classes, 93.3% of the participants were female and 6.7% were male. In the traditional classes, 98.3% of the participants were female and 1.7% were male. The class standings of the IBL students were 2.3% freshmen, 38.6% sophomores, 47.7% juniors, and 11.4% seniors. In the traditional classes, 1.7% of the participants were freshmen, 56.9% were sophomores, 34.5% were juniors, and 6.9% were seniors.

In the IBL classes, 34.1% of the students were PreK-3 early childhood education majors, 47.7% were 1-5 elementary education majors, and 18.2% were 4-8 middle school education majors. Of the middle school education majors, 25% had math education as one of their focus areas. In the traditional classes, 28.0% of the students were PreK-3 early childhood education majors, 59.6% were 1-5 elementary education majors, and 12.3% were 4-8 middle school education majors with 71.4% of the middle school education majors having math education as a focus area.

The majority of the IBL students (59.1%) had GPAs of 2.01 to 3.0, inclusive. For the other IBL students, 4.5% had GPAs of no more than 2.0 and 36.4% had GPAs of at least 3.01. This differs from the traditional classes in which the majority of those students (55.2%) had GPAs of at least 3.01 with 1.7% having GPAs no higher than 2.0 and 43.1% having GPAs of 2.01 to 3.0, inclusive. In the previous mathematics course, Math 177 – Mathematics for Elementary Teachers I, 11.4% of the IBL students earned a grade of A, 68.2% earned a grade of B, and 20.5% earned a grade of C. The grade distribution of the students in the traditional classes was slightly more balanced with 38.6% earning a grade of A, 36.8% earning a grade of B, and 24.6% earning a grade of C.

In the IBL classes, 65.9% of the students had never enrolled in an IBL course prior to the semester of the study compared to 43.9% of the traditional students. Only 20.5% of the IBL students enjoyed their math classes often or always, 45.5% sometimes enjoyed their math classes, and 34.1% rarely or never enjoyed their math classes. The traditional students were more likely to have enjoyed their math classes with 37.9% having enjoyed their math classes often or always, 36.2% having sometimes enjoyed their math classes, and 25.9% having rarely or never enjoyed their math classes. Table 1 summarizes the demographic data.

Assumptions

For all analyses, assumptions were checked using appropriate graphs and tests in SPSS. Boxplots were constructed for all variables, and outliers were examined. Two outliers that resulted from typographical errors were corrected, and any outliers that were accurate data values remained in the data set for analysis. Several violations in normality were found through Q-Q plot analysis for self-reported levels of understanding in the

Table 1

Demographic Data

Characteristic	IBL		Traditional	
	Frequency	Percentage	Frequency	Percentage
Class Level				
Freshman	1	2.3%	1	1.7%
Sophomore	17	38.6%	20	56.9%
Junior	21	47.7%	33	34.5%
Senior	5	11.4%	4	6.9%
Major				
Grades PreK-3	15	34.1%	16	28.0%
Grades 1-5	21	47.7%	34	59.6%
Grades 4-8	8	18.2%	7	12.3%
GPA				
≤ 2.00	2	4.5%	1	1.7%
2.01 – 3.00	26	59.1%	25	43.1%
3.01 – 4.00	16	36.4%	32	55.2%
177 Grade				
A	5	11.4%	22	38.6%
B	30	68.2%	21	36.8%
C	9	20.5%	14	24.6%
Previous IBL				
Yes	15	34.1%	32	56.1%
No	29	65.9%	25	43.9%
Enjoy Math Classes				
Yes	9	20.5%	22	37.9%
Sometimes	20	45.5%	21	36.2%
No	15	34.1%	15	25.9%

participants' journals. However, analyses were performed regardless due to ANOVA being robust against violations of normality (Schmider, Ziegler, Danay, Beyer, & Buhner, 2010). Homogeneity of variances between the IBL and traditional groups was assessed using Levene's test for equality of variances, and Mauchly's test of sphericity was used to assess the variance of the differences between self-reported math anxiety and understanding from the journal entries. Any cases of violations to homogeneity of variances or sphericity are specifically discussed in the presentation of results.

Research Hypothesis 1

A two-way repeated measures ANOVA was run with the between-subjects factor as the instructional strategy and the within-subjects factor as the MARS-S scores. The results show that there was a statistically significant interaction between the instructional strategy and the time elapsed over the course of the semester on the MARS-S scores, $F(1, 95) = 11.91$, $p = .001$, partial $\eta^2 = .111$. Because there were only two instructional strategies (IBL and traditional) and two time periods (initial and final), the tests for simple main effects resulted in the same outcomes as the *t*-tests below.

Independent samples *t*-tests were run to determine if there were differences in the initial and final MARS-S scores of the students in the IBL and traditional classes. Table 2 summarizes the initial and final MARS-S scores for the IBL and traditional students. Initial MARS-S scores for the IBL students ($M = 85.00$, $SD = 17.71$) were higher than the scores for the traditional students ($M = 76.17$, $SD = 21.19$), a statistically significant difference, $M = -8.83$, 95% CI [–16.73, –0.93], $t(99) = -2.22$, $p = .029$, $d = 0.45$. Even though the MARS-S scores of the IBL students decreased and the MARS-S scores of the traditional student increased over the course of the semester, there was not a statistically significant difference in the final MARS-S scores between the IBL ($M = 79.84$, $SD = 18.50$) and traditional students ($M = 81.95$, $SD = 18.67$), $M = 2.11$, 95% CI [–5.37, 9.59], $t(97) = .56$, $p = .577$, $d = 0.11$.

Paired samples *t*-tests were also run for the IBL and traditional classes' initial and final MARS-S scores. The IBL classes had a statistically significant difference in initial and final MARS-S scores with final MARS-S scores ($M = 80.00$, $SD = 18.90$) being statistically significantly lower than initial MARS-S scores ($M = 86.24$, $SD = 17.18$), $M =$

Table 2

Initial and Final MARS-S Scores for Independent Samples t-Test

MARS-S Scores	IBL			Traditional		
	n	Mean	SD	*n*	Mean	SD
Initial*	43	85.00	17.71	58	76.17	21.19
Final	43	79.84	18.50	56	81.95	18.67

Note. * indicates a statistically significant difference between instructional strategies.

6.24, 95% CI [2.59, 1.01], $t(40) = 2.41$, $p = .021$, $d = 0.38$. The traditional classes also had a statistically significant difference in initial and final MARS-S scores. However, in this case, final MARS-S scores ($M = 81.95$, $SD = 18.67$) were higher than initial MARS-S scores ($M = 76.59$, $SD = 21.19$), $M = -5.36$, 95% CI $[-9.69, -1.02]$, $t(55) = -2.48$, $p = .016$, $d = 0.33$. Table 3 presents the summary statistics from the paired *t*-tests, and Figure 2 displays the mean MARS-S scores.

Table 3

Initial and Final MARS-S Scores for Paired Samples t-Test

MARS-S Scores	IBL†			Traditional†		
	n	Mean	SD	*n*	Mean	SD
Initial	41	86.24	17.18	56	76.59	21.19
Final	41	80.00	18.90	56	81.95	18.67

Note. † indicates a statistically significant difference within instructional strategies.

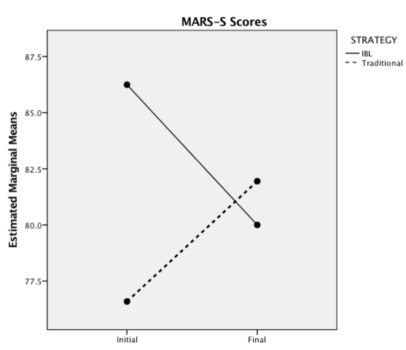


Figure 2. Mean MARS-S scores

Self-reported Math Anxiety. A two-way repeated measures ANOVA was run with the between-subjects factor as the instructional strategy and the within-subjects factor as the students' self-reported math anxiety scores from the journal entries. The results show that there was a statistically significant interaction between the instructional strategy and the time elapsed over the course of the semester on the self-reported math anxiety scores, $F(4, 328) = 7.57$, $p < .001$, partial $\eta^2 = .085$. Because there were only two instructional strategies (IBL and traditional), the tests for simple main effects of instructional strategy is the same as the independent samples *t*-tests presented below.

Independent samples *t*-tests were run to test for differences between each of the journal entries for the IBL and traditional classes. The summary statistics for each of the five journal entries based on instructional strategy are presented in Table 4. Significant differences were found between the classes for journal entry 1, $M = -1.55$, 95% CI [−2.57, −0.54], $t(94) = -3.03$, $p = .003$, $d = 0.62$; journal entry 2, $M = -1.21$, 95% CI [−2.19, −0.22], $t(96) = -2.44$, $p = .017$, $d = 0.51$; and journal entry 5, $M = 1.20$, 95% CI [0.18, 2.22], $t(96) = 2.33$, $p = .022$, $d = 0.47$. Mean self-reported math anxiety scores were higher for the IBL classes than the traditional classes for journal entries 1 and 2 at the beginning of the semester but were lower for journal entry 5, which was submitted during the last week of classes.

When testing for the simple main effects within each instructional strategy, Mauchly's test of sphericity indicated that the assumption of sphericity had been violated, $\chi^2(9) = 19.33$, $p = .023$. Therefore, degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .78$). This resulted in statistically

Table 4

Self-reported Math Anxiety (MA) for Independent Samples t-Test

MA Journal	IBL			Traditional		
	n	Mean	SD	*n*	Mean	SD
Journal 1*	43	6.93	2.40	53	5.38	2.57
Journal 2*	42	7.12	2.05	56	5.91	2.68
Journal 3	44	6.39	2.21	56	5.86	2.40
Journal 4	44	6.20	2.46	54	5.65	2.45
Journal 5*	44	5.73	2.46	54	6.93	2.60

Note. * indicates a statistically significant difference between instructional strategies.

significant differences in self-reported math anxiety for the IBL classes, $F(3.12,118.49) = 6.14$, $p = .001$, partial $\eta^2 = .139$. Pairwise comparisons show that self-reported math anxiety was statistically significantly reduced between journal entry 1 ($M = 7.00$, $SD = 2.44$) and journal entry 5 ($M = 5.59$, $SD = 2.51$), 95% CI [0.018, 2.803], $p = .045$. Significant differences in the self-reported math anxiety for the IBL group also existed between journal entry 2 ($M = 7.31$, $SD = 1.98$) and journal entry 5 ($M = 5.59$, $SD = 2.51$), 95% CI [0.451, 2.985], $p = .003$. There were also statistically significant differences in self-reported math anxiety for the traditional classes, $F(4,176) = 3.47$, $p = .009$, partial $\eta^2 = .073$. Pairwise comparisons for the traditional classes indicated that self-reported math anxiety was statistically significantly increased between journal entry 1 ($M = 5.42$, $SD = 2.55$) and journal entry 5 ($M = 6.78$, $SD = 2.72$), 95% CI [−2.616, −0.095], $p = .027$. There was also a significant increase between journal entry 3 ($M = 5.62$, $SD = 2.41$) and journal entry 5 ($M = 6.78$, $SD = 2.72$), 95% CI [−2.167, −0.144], $p = .015$. A significant increase also existed between journal entry 4 ($M = 5.58$, $SD = 2.65$) and journal entry 5 ($M = 6.78$, $SD = 2.72$), 95% CI [−2.298, −0.102], $p = .023$. Table 5 presents the summary statistics used in the pairwise comparisons of the self-reported math anxiety scores for each of the journal entries, and Figure 3 displays the mean self-reported math anxiety scores.

Table 5

Self-reported Math Anxiety (MA) for Pairwise Comparisons

MA Journal	IBL			Traditional		
	n	Mean	SD	*n*	Mean	SD
Journal 1	39	7.00†	2.44	45	5.42†	2.55
Journal 2	39	7.31†	1.98	45	5.87	2.80
Journal 3	39	6.41	2.20	45	5.62†	2.41
Journal 4	39	6.23	2.56	45	5.58†	2.65
Journal 5	39	5.59	2.51	45	6.78	2.72

Note. † indicates a statistically significant difference between noted journal entry and journal entry 5 within instructional strategies.

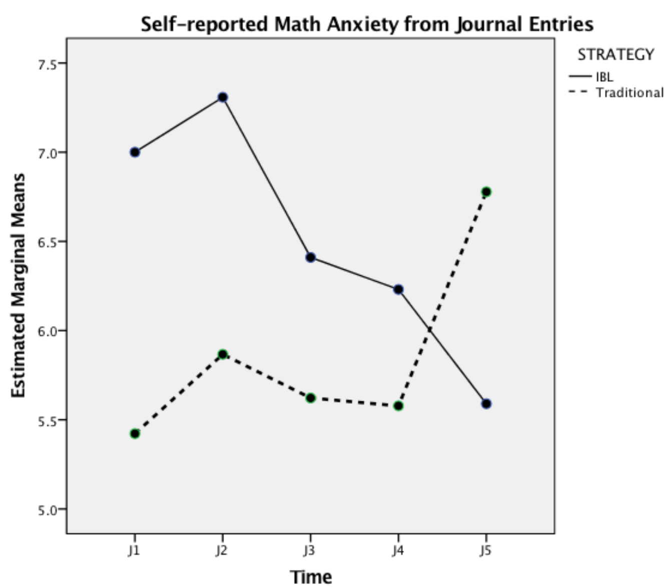


Figure 3. Mean self-reported math anxiety levels

Research Hypothesis 2

A two-way repeated measures ANOVA was run with the between-subjects factor as the instructional strategy and the within-subjects factor as the content knowledge scores. The results show that there was not a statistically significant interaction between the instructional strategy and the time elapsed over the course of the semester on the content knowledge scores, $F(1, 99) = 0.75$, $p = .389$, partial $\eta^2 = .008$. Table 6 summarizes the initial and final content knowledge scores for the IBL and traditional students, and Figure 4 displays the mean content knowledge scores. While there was no statistically significant difference between initial and final content knowledge scores when factoring in instructional strategy, there was a statistically significant main effect of instructional strategy between the pre-test and post-test scores, $F(1, 99) = 212.92$, $p < .001$, partial $\eta^2 = .683$. Based on the results of paired samples *t*-tests, there were statistically significant differences between the initial and final scores for the IBL classes, $M = -4.41$, 95% CI [−5.28, −3.54], $t(43) = -10.24$, $p < .001$, $d = 1.54$, as well as for the traditional classes, $M = -4.97$, 95% CI [−5.88, −4.05], $t(56) = -10.89$, $p < .001$, $d = 1.44$.

Table 6

Initial and Final Content Knowledge (CK) Scores for Paired Samples t-Test

CK Scores	IBL			Traditional			Combined Groups		
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
Initial†	44	7.34	2.15	57	7.30	1.98	101	7.32	2.04
Final†	44	11.75	2.75	57	12.26	3.17	101	12.04	2.99

Note. † indicates a statistically significant difference within instructional strategies.

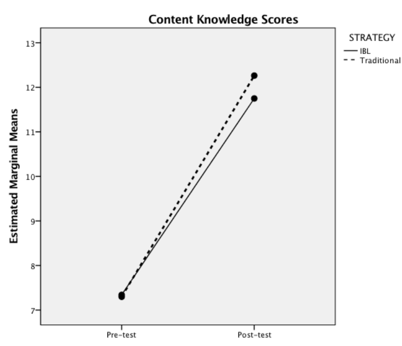


Figure 4. Mean content knowledge scores

Self-reported Understanding. A two-way repeated measures ANOVA was run with the between-subjects factor as the instructional strategy and the within-subjects factor as the students' self-reported levels of understanding of course material in their journal entries. The results show that there was not a statistically significant interaction between the instructional strategy and the time elapsed over the course of the semester on the self-reported level of understanding, $F(3, 222) = 1.07$, $p = .363$, partial $\eta^2 = .014$. However, there was a statistically significant main effect of instructional strategy between the journal entries, $F(3, 222) = 3.87$, $p = .010$, partial $\eta^2 = .050$. There was a statistically significant increase in self-reported understanding from journal 2 ($M = 5.62$, $SD = 2.23$) to journal 3 ($M = 6.54$, $SD = 2.08$), 95% CI [−1.52, −0.34], $p = .002$. A significant increase was also found between journal 2 ($M = 5.62$, $SD = 2.23$) and journal 4 ($M = 6.21$, $SD = 1.96$), 95% CI [−1.24, −0.03], $p = .040$. There was a statistically significant increase in self-reported understanding from journal 2 ($M = 5.62$, $SD = 2.23$) to journal 5 ($M = 6.22$, $SD = 2.30$), 95% CI [−1.24, −0.14], $p = .014$. Table 7 summarizes the self-reported levels of understanding from the journal entries for the IBL and traditional students, and Figure 5 displays the mean self-reported levels of understanding. Because journal entry 1 was collected on the second day of class, students were not asked to discuss their level of understanding of course material, only their math anxiety.

Correlational Analysis

Pearson's correlation coefficient was computed between students' self-reported levels of math anxiety and understanding, as well as initial and final MARS-S and content knowledge scores. Notable correlations include the statistically significant

Table 7

Self-reported Level of Understanding (UN)

UN	IBL			Traditional			Combined Groups		
	n	Mean	SD	*n*	Mean	SD	*n*	Mean	SD
Journal 2	31	5.35	1.85	45	5.80	2.45	76	5.62	2.23
Journal 3	31	6.35	2.14	45	6.67	2.46	76	6.54†	2.08
Journal 4	31	6.23	2.08	45	6.20	1.93	76	6.21†	1.96
Journal 5	31	6.52	2.01	45	6.02	2.47	76	6.22†	2.30

Note. † indicates a statistically significant difference from journal entry 2.

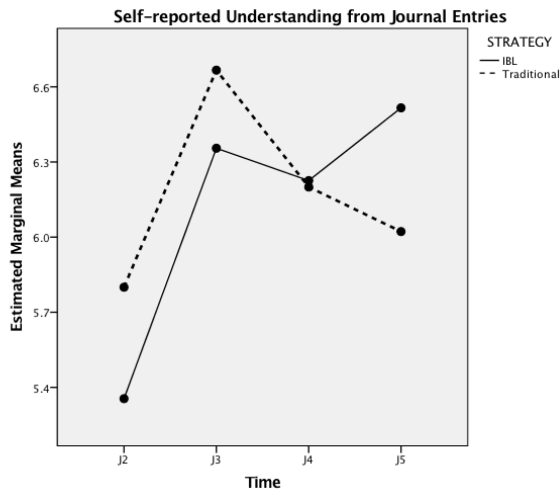


Figure 5. Mean self-reported levels of understanding

negative relationship between each self-reported level of math anxiety with its corresponding self-reported level of understanding, indicating that as math anxiety scores increased, students' levels of understanding decreased (journal entry 2: $r(93) = -.52$, $p < .01$; journal entry 3: $r(92) = -.40$, $p < .01$; journal entry 4: $r(86) = -.56$, $p < .01$; journal entry 5: $r(89) = -.37$, $p < .01$). There was also a strong positive correlation between students' initial and final MARS-S scores, $r(95) = .61$, $p < .01$, whereas a weak negative correlation existed between students' final MARS-S scores and final content knowledge scores, $r(97) = -.28$, $p < .01$. A statistically significant strong positive correlation existed between students' initial MARS-S scores and their self-reported level of math anxiety at the beginning of the semester on journal entry 1, $r(92) = .65$, $p < .01$. Final MARS-S scores and the students' self-reported level of math anxiety at the end of the semester on journal entry 5 were moderately positively correlated, $r(94) = .49$, $p < .01$. The results are summarized in Table 8. The strength of the correlation was reported based on benchmarks provided by Cohen (1988).

Final Questionnaire Results

At the conclusion of the semester, participants were asked on the follow-up questionnaire to rate their opinions on their classroom experiences and preferences in mathematics classes on a 5-point Likert scale. Independent samples *t*-tests were performed comparing the responses of the IBL and traditional classes. Table 9 summarizes the results of the *t*-tests. There were statistically significant differences in the responses between the IBL and traditional classes for 12 of the 14 statements. The IBL classes scored higher in regard to the

- likelihood they will incorporate a similar strategy in their own classes,
- enjoyment of the instructional strategy,
- helpfulness of the instructional strategy in helping them become better problem solvers,
- learning more than they expected to learn,
- being intellectually challenged,
- encouraging them to find unique solutions,
- learning by solving problems using their own methods,

Table 8

Correlations

Measure	1	2	3	4	5	6	7	8	9	10	11	12
1. IN.MARS												
2. FI.MARS	.61**											
3. IN.CK	−.14	−.26**										
4. FI.CK	−.25*	−.28**	.24*									
5. J1MA	.65**	.33**	−.11	−.18								
6. J2MA	.50**	.41**	−.13	−.29**	.49**							
7. J3MA	.42**	.43**	−.25*	−.40**	.45**	.34**						
8. J4MA	.49**	.48**	−.29**	−.49**	.45**	.43**	.58**					
9. J5MA	.19	.49**	−.25*	−.42**	.28**	.32**	.56**	.57**				
10. J2UN	−.24*	−.34**	.08	.33**	−.16	−.52**	−.20	−.17	−.25*			
11. J3UN	−.33**	−.43**	.14	.24*	−.19	−.14	−.40**	−.28**	−.33**	.32**		
12. J4UN	−.37**	−.46**	.37**	.40**	−.25*	−.16	−.38**	−.56**	−.48**	.26*	.51**	
13. J5UN	−.10	−.21	−.02	.21	−.08	−.18	−.15	−.21*	−.37**	.41**	.32**	.30**

Note. IN.MARS = initial MARS-S score, FI.MARS = final MARS-S score, IN.CK = initial content knowledge score, FI.CK = final content knowledge score, J1MA = journal 1 math anxiety level, J2MA = journal 2 math anxiety level, J3MA = journal 3 math anxiety level, J4MA = journal 4 math anxiety level, J5MA = journal 5 math anxiety level, J2UN = journal 2 understanding level, J3UN = journal 3 understanding level, J4UN = journal 4 understanding level, J5UN = journal 5 understanding level. **p* < .05. ***p* < .01

- being capable of learning new mathematics on their own,
- having greater confidence in their mathematics skills than before taking the course,
- looking forward to coming to class, and
- having the class be a positive experience.

The traditional classes had a higher score than the IBL classes for only one of the 14 statements, “I prefer math classes in which the teacher uses traditional teaching methods.” While the assumption of homogeneity of variances was violated as assessed by Levene’s test for equality of variances ($p < .001$), this was a statistically significant difference, $M = 0.72$, $SE = 0.19$, $t(64.84) = 3.62$, $p = .001$. There was no statistically significant difference between the classes in their preference to work with peers in class rather than work independently, $M = -0.18$, $SE = 0.21$, $t(97) = -0.86$, $p = .394$.

Qualitative Data Analysis

The researcher listened to the qualitative data obtained from the focus groups and realized that one of the moderators did not follow protocol. Thus, the data from the focus groups were not considered in the analysis. Due to the large amount of qualitative data collected from journal entries, random samples of data were chosen. The 58 participants in the traditional classes were numbered 1-58, whereas the 45 participants from the IBL classes were numbered 1-45. Using these values, ten percent of participants from each group were selected using a random number generator for each of the journal entries. The journals were carefully read through and emerging themes were noted. Once a list of emerging themes was identified, all of the sampled data was read through once again and coded accordingly. A summary of how the preservice teachers described their

Table 9

Independent Samples t-Tests for Student Opinions on Final Questionnaire

Statement	IBL (n = 43)		Traditional (n = 56)			
	Mean	SD	Mean	SD	t	p
I am likely to incorporate a similar instructional strategy in my own classroom.*	3.35	1.15	2.43	1.19	−3.87	< .001
I enjoyed the instructional strategies used in Math 277.*	3.12	1.22	2.25	1.08	−3.74	< .001
I prefer math classes in which the teacher uses traditional teaching methods.*	3.42	1.16	4.14	.67	3.62	.001
I prefer to work with my peers in class rather than work independently.	3.84	1.11	3.66	.94	−.86	.394
The instructional strategy used in this class has helped me be a better problem solver.*	3.81	1.16	2.41	1.14	−6.02	< .001
I learned more than I expected to learn.*	3.88	1.05	2.41	1.14	−6.59	< .001
I was intellectually challenged by the course.*	4.60	.54	4.09	.96	−3.16	.002
The instructional strategy used in this class has encouraged me to find unique solutions to problems.* †	3.95	.90	2.68	1.13	−6.25	< .001
Solving a problem using my own method helps me learn better.*	4.00	.85	3.63	.98	−2.00	.049
I felt motivated to work when I came to class.*	3.49	1.06	2.30	1.08	−5.47	< .001
I am capable of learning new mathematics on my own.*	3.47	1.16	2.84	1.04	−2.82	.006
I have greater confidence in my mathematics skills now than before taking this course.*	3.49	1.28	2.04	1.04	−6.22	< .001
I looked forward to coming to Math 277 class.*	3.05	1.13	2.02	1.00	−4.79	< .001
This class was a positive experience for me.*	3.33	1.27	2.04	1.01	−5.64	< .001

Note. * indicates a statistically significant difference between instructional strategies. † indicates the assumption of homogeneity of variances was not met as indicated by Levene's test for equality of variances.

experiences in Math 277 in regard to their math anxiety and mathematics achievement is discussed.

Themes

The themes that emerged during the coding process included course content, teaching methods, assessment, and student behaviors. Results from the IBL participants in each theme are presented first followed by results from the traditional participants.

Course Content. Participants in both groups stated that general course content, specific materials and models, and the conceptual nature of the course impacted their math anxiety and understanding of course content. Participants in the traditional group also stated that the homework and amount of course content impacted their math anxiety and understanding.

IBL Group

Participants enrolled in the IBL classes attributed general course content to both increased and decreased levels of math anxiety. Whereas one participant would be confident and have little anxiety in a content area, someone else would be more anxious. One participant with high anxiety and moderate understanding reflected upon fraction problems by stating, “I am just really confused on the correct way to work them out or solve them. I do not fully understand the course material up to this point and it is very frustrating.” Another with moderate anxiety reported, “When I see fractions, I just go blank and I need to get over the fear of fractions and embrace them.” A participant who was more confident regarding fractions and was concerned with how to help elementary students understand stated, “The material itself isn’t complex, hard material.”

Several IBL participants discussed anxiety and understanding course content related to specific materials and models used in class. Regarding pattern blocks, one participant with moderate anxiety and low understanding stated, “I get confused knowing what each one stands for and how to multiply fractions using the pattern blocks.” Another participant with high anxiety and moderate understanding reflected, “I can work with the pattern blocks because they make sense to me, but I find it hard to show problems using number lines or arrays.” A third participant with moderate anxiety expressed, “I just feel that as the tree diagram gets bigger, I get overwhelmed with all the different ways that a sample space can be generated and I feel like I am going to miss something and I usually do.” A moderately-anxious participant was confused by “modeling different fractions or decimals on number lines.” Someone else with decreasing anxiety and high understanding remarked, “I am progressing with the understanding of using models to demonstrate my work. The pattern blocks really helped me to visualize each piece.”

Some participants in the IBL classes reflected upon the conceptual nature of the course content. One participant with moderate anxiety and understanding stated that she had “a hard time getting [her] mind to work a different way than [she was] used to.” A different participant with moderate, yet decreasing anxiety reflected that she was “still struggling with explaining why each particular method works.” Another with moderate anxiety reflected,

> “It’s sometimes hard for me to break down the problem into parts and steps that a younger student would be able to understand. It takes some time to think about that instead of just doing certain problems the way you know how to do them.”

At the end of the course, one participant who "mastered the concepts" stated,

> "I understand certain mathematical strategies now more than I ever could have imagined. I can answer why certain things work and do not work. To me, this is more important than just memorizing formulas or spouting off definitions. I will be able to teach with confidence."

She later reported, "I do not feel the cutting-anxiety or the gut-wrenching stress I felt at the beginning of the semester."

Traditional Group

Participants in the traditional classes also implied that general course content, specific materials, and the conceptual nature of the course affected their math anxiety and understanding. Traditional class participants also suggested that the amount of content and the homework problems contributed to their math anxiety. Course content focused on the units of fractions, decimals, and probability tended to cause more anxiety than data analysis. One participant with high self-reported anxiety stated that she was "worried about fractions," whereas another said, "Fractions have always made me nervous in math. I find them confusing and hard to work with." Another participant with high anxiety reflected after receiving a grade on a test, "I did not understanding [*sic*] unit 2 [decimals] and 3 [probability] as well as I thought." A different participant with moderate anxiety and understanding commented, "Probability is a subject that bewilders me." Another stated, "The beginning of both decimals and probability I feel I have a strong grasp of understanding but when it comes to the end of both sections I feel a little lost." During the data analysis unit, one participant with high understanding reflected, "I enjoy learning this unit because it will help me with my profession in the future; for example, this material helped me to understand different ways to organize students' test grades." While one participant felt that the class "covered many different topics" and she needed "additional practice with all of them," others felt that they "understood the material pretty well" and were "able to learn and connect every concept taught during the semester."

Traditional participants had differing views on how specific materials and models affected their anxiety and understanding of course material. One participant with high anxiety stated,

> "The pattern blocks are the hardest part to get because I'm really not use [*sic*] to doing that when in math. We always used pencil and paper to solve a math problem so having this hands on way is new and a little confusing for me."

Another participant with a low level of understanding but high anxiety expressed, "Pattern blocks still confuse me. I am fine using them for adding. They actually help with subtracting fractions. As far as multiplying goes, the pattern blocks hinder me." This same participant also reflected, "An area [model] confuses me. It is hard for me to understand how to effectively use an area [model]…Word problems are another one of my weak areas." A different participant with moderate anxiety but high understanding said,

> "In the beginning I was having a hard time understanding the pattern blocks, but know [*sic*] I view them as a visual tool. I really like working with them now because they allow me to see how the problems are broken down and using them makes it easier to solve the given problems."

Although another participant felt her anxiety increased throughout the semester, she "did learn new approaches to teach, such as using pattern blocks and visual diagrams for teaching." She later comments that these methods "are what is best for a student of any age to learn."

Participants in the traditional classes also had difficulty with the conceptual nature of the course and attributed it to their anxiety. Early in the semester, one participant with high anxiety and high understanding stated,

> "I still am very anxious about the class and the way we have to do some of the problems is very different from what I'm used to…. My brain keeps wanting me to do it the way we learned it in school."

Another student with high anxiety said, "The way we approach solutions to the assigned problems is completely different than I am use [sic] to. In elementary [school] I was never taught the 'why' of the problems, just the how." One participant responded that even though her anxiety was low, she was still anxious "from the thought of not being able to use a standard mathematical algorithm to solve the problems." One participant with low math anxiety and a high level of understanding discussed the conceptual nature of the course content. She remarked,

> "Some the problems are 'why?' questions which I have a difficult time answering because I myself don't always know why. …I have always been taught that math is universal and its methods work just because someone said they did. In my experience, 'why?' was not a question that needed to be answered."

Even though one participant had low anxiety and moderate anxiety, she had strong views about the conceptual nature of the course. She commented,

> "I have never used any other mathematical algorithms beside the standard ones; that is how I learned math in elementary school. I don't understand why we are

not allowed to use standard algorithms; even though young students learn through common core, I feel that it is best for them to learn how to solve math problems using standard algorithms. It is easier and will help them be able to solve math problems in their adult lives, rather than complicating a simple math problem that will take them much longer to solve all because they were taught that they need to be able to better understand the material."

In the end-of-semester journals, three participants reflected on the conceptual nature of the course. One participant reflected,

> "My overall anxiety regarding math has gone up because it has allowed me [to] see that not all math is understanding and easy. This math has made me work super hard and for that I am both happy and scared. I am happy that this class has pushed me to see math in a while [*sic*] different language. I am scared to think that there is other math out there that is not as easy as what I have been seeing my whole life."

Another participant with a "decent" level of understanding commented,

"Most of the formulas I merely memorize. Granite [*sic*] there are a few that I understand why we do what we do, but for the most part I only do what I am shown because that is how I was shown."

The third participant with a "mastery" level of understanding stated, "This material…was shown in a different way that involved a little more thinking. I like the concepts however and I enjoyed learning about them."

Participants in the traditional class also attributed the homework problems to their math anxiety. One with high anxiety stated, "When I do the homework I am confused because the problems are not like the problems covered in class." Others had the same opinion. A participant with moderate anxiety remarked, "I find myself confused about 80% of the time when doing the homework for this class because it is [*sic*] almost always seems so different from the examples we did in class," whereas another said, "I find that the homework is ten times harder than the class work." Another participant with both moderate anxiety and understanding commented feeling frustrated about the homework because "it seems as though the problems are easy enough, but they are always more complicated then [*sic*] appear." She later says, "When I get home and do the homework I end up confused and feel like I never truly did understand what I learned." One participant who had increasing anxiety throughout the semester reflected, "What we learned in class was completely opposite from the homework and the test and that is what caused the most of my math anxiety to increase." Another participant with moderate anxiety stated,

> "I still don't like how different the homework is from the stuff we do in class. I understand that it is there to make us think but when we don't know if we are doing it right or not then there is really no point in doing it."

Some participants reflected upon how the homework helped improve their understanding and lower their anxiety. One participant stated, "I do not have much anxiety about the material because I think I am doing okay with the homework as well as the classwork." Another said, "I thought the homework reflected the class work well and was a good demonstration of understanding."

Unlike participants in the IBL classes, participants in the traditional classes discussed how the amount of course content affected their anxiety. One participant with moderate anxiety stated, “There was so much information given, it was hard to master all of the concepts.” Another said, “I feel a bit anxious to learn the other math material because I don’t know if I’ll be able to remember it.” A different student with high anxiety felt that the class “rushed through all the course materials that needed to be covered.” Table 10 summarizes the course content theme and provides exemplars for each group.

Table 10

Exemplars of course content theme by group and anxiety level

Sub-theme	Group	Anxiety Level	Exemplar
General Course Content	IBL	Low	“The material itself isn’t complex, hard material.”
		High	“I am just really confused on the correct way to work them [fractions] out or solve them. I do not fully understand the course material up to this point and it is very frustrating.”
	Traditional	Moderate	“The beginning of both decimals and probability I feel I have a strong grasp of understanding but when it comes to the end of both sections I feel a little lost.”
		High	“Fractions have always made me nervous in math. I find them confusing and hard to work with.”
Materials and Models	IBL	Moderate	“I am progressing with the understanding of using models to demonstrate my work. The pattern blocks really helped me to visualize each piece.”
		High	“I can work with the pattern blocks because they make sense to me, but I find it hard to show problems using number lines or arrays.”
Materials and Models	Traditional	Moderate	“In the beginning I was having a hard time understanding the pattern blocks, but know [*sic*] I view them as a visual tool. I really like working with them now because they allow me to see how the problems are broken down and using them makes it easier to solve the given problems.”

Table 10 (continued).

Materials and Models	Traditional	High	"The pattern blocks are the hardest part to get because I'm really not use [*sic*] to doing that when in math. We always used pencil and paper to solve a math problem so having this hands on way is new and a little confusing for me."
Conceptual Nature	IBL	Low	"I understand certain mathematical strategies now more than I ever could have imagined. I can answer why certain things work and do not work. To me, this is more important than just memorizing formulas or spouting off definitions. I will be able to teach with confidence."
		Moderate	"I have a hard time getting my mind to work a different way than I am used to."
	Traditional	Low	"Some the problems are 'why?' questions which I have a difficult time answering because I myself don't always know why. …I have always been taught that math is universal and its methods work just because someone said they did. In my experience, 'why?' was not a question that needed to be answered."
		High	"I still am very anxious about the class and the way we have to do some of the problems is very different from what I'm used to…. My brain keeps wanting me to do it the way we learned it in school."
Homework	Traditional	Low	"I thought the homework reflected the class work well and was a good demonstration of understanding."
		High	"When I do the homework I am confused because the problems are not like the problems covered in class."
Amount of Course Content	Traditional	Moderate	"There was so much information given, it was hard to master all of the concepts."
		High	"[The class] rushed through all the course materials that needed to be covered."

Teaching Methods. The IBL and traditional participants stated that aspects of the teaching method impacted their math anxiety and understanding of course content. There were differing views on the teaching methods within each group.

IBL Group

Early in the semester, there were differing views from the participants in the IBL classes regarding the teaching methods used in the course. One participant with moderate self-reported anxiety stated that she was “comfortable with the way the class is ran,” whereas another who also had moderate anxiety said, “I cannot learn the way we are being told to learn....Not having someone teach me the material has not only given me major anxiety, but it has also caused me to be very confused on what is going on.” A different student with high anxiety reflected, “Without being given any instructions it is difficult for me to know the correct way to work out the math problems.” As the semester progressed, participants became more comfortable with the teaching methods. One participant with high anxiety and moderate understanding commented, “Once I get used to then [*sic*] new method of learning that I have been introduced to I will be okay and understand better.” Another with moderate anxiety and understanding responded, “I am now somewhat used to the routine in the classroom and it is going smoother than before.” Midway through the semester is when all participants responded positively toward the methods. One participant reflected, “I am used to the way we are learning in the setting of the class so it does not stress me out or give me any anxiety….I am confident and comfortable with the class and its material.” Another with moderate, yet decreasing anxiety, stated,

> "I have started to let my guard down in the math sense and have allowed myself to embrace the new method of math and find that there can be true joy in working through problems. Once the answer reveals itself there is such a feeling of accomplishment that absolutely cannot be beat."

Toward the end of the semester, one participant whose anxiety had decreased to a low level said regarding the teaching methods, "I stop[ped] worrying about how the information is taught, which was the barrier allowing me to have trouble processing information…I now have a complex understanding of what is being taught." The participant later stated "I [understand] the importance of understanding information instead of reciting details that is usually taught in math classes." Another participant with high anxiety and moderate understanding commented that she has "learned that it is just a different way of learning but you do still learn a lot from it." At the end of the semester, participants reflected upon their experiences in the course regarding the teaching methods. One participant stated,

> "The act of learning is truly amazing. You can learn anything at any time in any place. I did not *need* a teacher or even a textbook to learn! In fact, I carried most of the knowledge already. I just needed someone to facilitate thought and require a little thinking."

Another IBL participant reflected,

> "I was very closed to the idea in the beginning but as I opened myself up and thought positively about the instruction of the course, I began to excel in class. Through positive outlook, I was able to come to terms with the class and realize how beneficial the instruction was to my knowledge."

Another participant stated that she was "rather content about [the approach]."

Several IBL participants commented specifically on particular aspects of the teaching method, including student presentations and group work. In regard to the daily student presentations of homework problems, one highly-anxious participant said at the beginning of the semester, "It helps seeing someone else work but trying to understand there [*sic*] work and redo it is difficult." Another participant with high anxiety commented,

> "All I have to rely on is paying attention to other students [*sic*] work in class and seeing how they work it and it can be good and bad because everyone thinks different and when I see different ways I sometimes get confused."

A different participant with low anxiety throughout the semester reflected, "I took from this class…being able to get up in front of the class and talk….[The instructor] made it so that we will be comfortable." Another who was confident in her understanding stated, "I loved the groups and getting to know my classmates. I liked seeing their thoughts and getting their opinions on different problem-solving strategies." Lastly, a participant who was worried about the teaching method at the beginning of the semester later commented, "Getting feedback and listening to each presentation in class has really helped me to improve my understanding for each mathematical topics [*sic*] discussed….I am very grateful for the way the class was taught."

Traditional Group

Participants in the traditional classes tended to have positive views regarding the teaching methods early in the semester, but there were both positive and negative views by the end of the semester. One participant with low anxiety stated, "I am also extremely happy that I am in the traditional class. I feel like my anxiety would have a much higher rating on the scale if I was not in the traditional class." A different participant with moderate anxiety expressed,

> "I have a better understanding of how everything will work, [and] I am not as anxious about it. I find comfort in how the class works. I love that it is all very organized and I fully understand what is expected of me and when."

A participant with moderate anxiety and high understanding believed that "Being in the traditional class definitely helps give [her] ideas and examples to follow." One aspect of the teaching method that most students felt contributed to increased levels of anxiety was regarding the homework. One participant reflected, "With the traditional strategy, the professor did not have time to review all of our homework and other exams, therefore I felt as though I did not know if I were doing certain things correctly." Others felt that "it would be very helpful if we actually reviewed the homework problems in class" and wished "there was more class time to review the more challenging homework problems." In the end-of-semester journals, one of the participants expressed that the teaching method "provided [her] with more anxiety than more learning." She later commented, "I am certain that the material that we've learned throughout the semester should be taught in a different manner." Another with moderate anxiety remarked,

> "I think that the instructional strategy being used may be affective [*sic*] for other students but for me I find it rather difficult….At first, I was angry all the time because I felt as if I did not understand anything. I blamed everything on the way it was being taught but as the semester carried on I figured out that I could learn

and listen a different way in which everything would make more sense. Bringing positivity to the subject allowed me to learn a little easier and grow more."

Others did not share that same viewpoint. Two highly-anxious participants stated that they "really liked the instructional strategy [the instructor] used to teach us" and "the instructional strategy is taught well by the teacher." Lastly, one participant reflected, "I find that it is the way I learn better. By watching the teacher work the problems, I understand how to do the problems better." Table 11 summarizes the teaching methods theme and provides exemplars for each group.

Table 11

Exemplars of teaching methods theme by group and anxiety level

Group	Anxiety Level	Exemplar
IBL	Low	"The act of learning is truly amazing. You can learn anything at any time in any place. I did not *need* a teacher or even a textbook to learn! In fact, I carried most of the knowledge already. I just needed someone to facilitate thought and require a little thinking."
	High	"All I have to rely on is paying attention to other students [*sic*] work in class and seeing how they work it and it can be good and bad because everyone thinks different and when I see different ways I sometimes get confused."
Traditional	Moderate	"I have a better understanding of how everything will work, [and] I am not as anxious about it. I find comfort in how the class works. I love that it is all very organized and I fully understand what is expected of me and when."
	High	"With the traditional strategy, the professor did not have time to review all of our homework and other exams, therefore I felt as though I did not know if I were doing certain things correctly."

Assessment. Participants in the IBL and traditional groups believed assessments, such as tests and the final exam, and concerns over their grades impacted their anxiety levels.

IBL Group

Several participants in the IBL classes contributed course assessments to their anxiety. In the second journal entry of the semester, one participant stated, "I'm really nervous about this first test," whereas another commented that she had high anxiety because "a test is going to be coming up soon and I'm nowhere near ready for a test."

Shortly after the first test, a participant reflected, "After I took my first test, I literally went to my car and cried. It made me feel really dumb. I went home and thought of ways to try and be more prepared for the next test." A different participant attributed her high anxiety to not knowing how she did on the first test and that she was "anxious about how [she] did on the test." Approximately halfway through the semester, one participant remarked that even though her anxiety was beginning to decrease, it was still high because she was "worried to death that the next test will be as rough as the first and [she's] heard horrible things about the final exam being worse than all of the other test [*sic*]." She later continued, "Most of my anxiety is related to my GPA. I've never made a C or below in a course; I'm wondering if I'm even going to pass this course." Another participant, who had very low self-reported math anxiety, said, "We have now taken our first test so I have experienced every aspect of the class. I know what to expect and I did well on the test….I know what I have to do to be successful." A participant with moderate self-reported anxiety attributed her level of anxiety to "finally [being] able to see [her] grade and know that [she] is doing well in the class," even though she later admitted, "The final does have me slightly worried since it is cumulative but I have faith." Toward the end of the semester, anxiety levels relating to assessments were still high. One participant with high self-reported math anxiety reflected, "I received a higher grade than I did on my first test on my second test which makes me feel a lot better." Another stated, "I am on the border of extreme anxiety. I came in prepared and totally went black [*sic*] when I sat down. I really need to work on test anxiety skills."

Traditional Group

Many of the traditional participants attributed their anxiety to class assessments, in particular tests, writing assignments, and concerns about their grades. One participant with high self-reported anxiety at the beginning of the semester stated, "The writing required in this course gives me some anxiety because this is the first math course that I've taken that requires writing." Leading up to the first test of the semester, a participant with high anxiety and low understanding remarked,

> "I am very nervous about our first math exam….I am worried that when it is time to take our exam, I will not be able to remember how to complete the problems from the first part of [the fractions unit]."

Another with moderate anxiety and understanding commented,

> "I am a little worried about the first test just because there is a lot of material covered within the first few sections….Another thing I worry about is how the test will be set up and more importantly, I wonder how the questions will be worded."

After taking the first test, participants experienced a decrease in math anxiety. One participant with moderate anxiety said," After the first unit and test of this course, my math anxiety somewhat decreased." A different participant with low anxiety responded,

> "I feel confident about the previous math test on fractions. Before I took the test, I made sure I knew the material and took the test with confidence. This lowered my anxiety a little and helped make me confident toward the tests to come."

Another participant with moderate anxiety and high understanding stated,

> "The day of the math test is the only time my anxiety level went up…because I was freaking out. I hate taking test [*sic*]. I always do horrible on test [*sic*] no matter…how much I study. My anxiety level will remain the same until I find out what I made on the first test."

Other participants believed their anxiety levels were "elevated in anticipation of the coming test[s]". One participant reflected, "It's getting closer to the test so I am becoming more and more nervous about it," whereas another commented, "The last unit test was hard for me and I am worried this one may be worse." Another participant felt high anxiety during a test as she "was panicking…and [her] mind went blank." By the end of the semester, participants with both low and high levels of anxiety throughout the course reflected on how the tests affected their anxiety. One participant stated,

> "The only time I had math anxiety during this course was before test [*sic*]. Just making sure I remembered all the information needed and not knowing [what] the test consisted of made me have a little anxiety. Also preparing for the final is making me have anxiety."

Another with high anxiety remarked,

> "With the knowing of a test coming up, my brain gets all worked up and I began to think of the worst possible scenario. As the semester went on, my anxiety began to get worse because of my poor first test score….When a test approaches, I feel as if my anxiety is at a 10 because I have to do well."

She was not the only participant concerned about having to do well. Several participants reported feeling anxiety because of concerns over their grades. One participant with moderate anxiety expressed, "I don't think I can get close to the grade I would want….I hope that my score can improve for the next test and that I can become more confident in the future with math." Another with moderate anxiety said, "I need to make a little higher grade in order to keep my scholarships, which is stressing me out more. I have never stressed out over any math class until now." Table 12 summarizes the assessment theme and provides exemplars for each group.

Student Behaviors. Participants in the IBL and traditional groups were able to attribute specific aspects of their thoughts and behavior that impacted their anxiety and understanding in both positive and negative ways.

IBL Group

At the beginning of the semester, high self-reported levels of math anxiety in the IBL classes were mostly due to participants' beliefs regarding their abilities to do mathematics. One participant stated, "I do not feel 'smart' at all while in math class….It's a subject that doesn't come natural to me." Another commented, "It stresses me out when I try and try and still don't understand it." As the semester progressed, many participants reported decreased levels of anxiety. One stated,

Table 12

Exemplars of assessment theme by group and anxiety level

Group	Anxiety Level	Exemplar
IBL	Low	"We have now taken our first test so I have experienced every aspect of the class. I know what to expect and I did well on the test….I know what I have to do to be successful."
	High	"I am on the border of extreme anxiety. I came in prepared and totally went black [*sic*] when I sat down [for the test]. I really need to work on test anxiety skills."
Traditional	Low	"The only time I had math anxiety during this course was before test [*sic*]. Just making sure I remembered all the information needed and not knowing [what] the test consisted of made me have a little anxiety. Also preparing for the final is making me have anxiety."
	High	"With the knowing of a test coming up, my brain gets all worked up and I began to think of the worst possible scenario. As the semester went on, my anxiety began to get worse because of my poor first test score….When a test approaches, I feel as if my anxiety is at a 10 because I have to do well."

> "In the beginning of this semester I would become frustrated and nervous as soon as I got stuck on a problem. I have noticed that I have not been giving up as easy and have been working on the problems until I figure out the solution."

Another participant with low self-reported math anxiety reflected,

> "I am learning to break down the questions into a way that I can better understand them. This is making the class easier for me. Another thing that is easing the anxiety is that if I really don't understand how to do something I look up videos that explain how to solve a similar problem and it makes solving my problems easier."

The previous participant later commented, “If I take my time and understand the question then solving it would be a lot easier.” Later in the semester, a participant with decreasing math anxiety realized what she needed to do to be successful by stating, “I figured that if I continue to do my homework correctly and complete my journals along with passing the tests, the best that I can, then I will be able to pass the class.” A different participant with decreasing anxiety also had a realization as to how to be successful. She said,

> “Our very first section I did not complete the whole section, all I did was the problems I did in class and the problems we had to turn in. But now I understand that [the instructor] did not give us all of those problems for us to not do them. [The instructor] knew it would help us by giving us more to practice on. I really wish I would have worked as hard as I do now whenever we first began.”

An IBL participant with low math anxiety at the end of the semester attributed her low anxiety to the methods she used outside of class. She stated,

> “I go home daily and review what was taught in class. Also making notes so I can review the assignment for the test....Even when I get my test I go back and review what I did incorrectly so I can gather an understanding of what was did [*sic*] wrong.”

Some participants with high self-reported anxiety were not as positive in their behaviors and thoughts. One participant remarked, “I also overthink a lot. My brother tells me that all the time while trying to help me with my homework. I think it has a lot to do with everything.” She later remarked that she had a tendency to second guess herself. Another participant commented, “My math anxiety will always be high because I am just not a number solving person….I am bad at math. Always…..Sometimes I confuse myself."

At the end of the semester, IBL participants reflected on their overall experiences and how they affected their anxiety. One participant commented,

> "Once I was able to understand that I needed to just think a little more…I became okay. It was a great feeling when I was able to figure out the problem on my own without assistance from others….I found it as a challenge, but I did not want to give up….This class taught me a lot about myself as a student. It showed me that I am capable of more than I give myself credit for. If I push myself than [*sic*] I can really be a great student which will lead me into being a great teacher."

A different participant stated,

> "I realized throughout the semester that I was more capable that [*sic*] I gave myself credit for. I realized that I was able to learn more and retain more information from figuring out the problems by myself rather than just memorizing the strategy shown like in other classes….I have learned to calmly and effectively solve problems on my own and that has really helped me to grow and lessen my math anxiety."

One participant who only experienced a small decrease in self-reported math anxiety remarked, "I have learned how to cope with [math anxiety] instead of letting it define who I am…. I learned that I have to stay optimistic and have a positive mindset in order to be successful."

Traditional Group

Student behaviors and beliefs in the participants in the traditional classes also had effects on their anxiety and understanding. One participant stated that in order to improve her understanding that she would have to "keep up with this math class and practice a lot….Practice makes perfect when it comes to learning math." Another felt that her moderate anxiety was partially due to her overthinking the problems. She stated, "I over analyze [the problems] and then find myself stuck on a simple problem. I second-guess myself often." Another moderately-anxious participant believed,

> "My anxiety for math never goes away because I am not and never have been a good math student and trying to cover everything in one class that I have never been able to understand before makes me really nervous and scared that I am going to miss something or forget a step and I will mess it all up."

A participant believed she had a strong understanding of course materials because of the study habits she employed. She stated,

> "Math requires more time and better study habits that [*sic*] any other subject for me. However, I believe this is important to ensure I will be a more successful educator when it comes to explaining the "whys" and "what ifs" of math….If I reason long enough I can usually figure out a non-standard way to approach the problem."

A different participant who also had a high understanding of course material remarked, "By relating [the material] to real life and studying the information repetitively, I am able to understand." She later comments, "As long as I continue to study and practice, I can apply that knowledge and understand the information that I need in order to pass the test." Another participant with low anxiety remarked, "Helping other students understand the material has improved my confidence in my own abilities. Doing this reinforces that I really understand the material, rather than just learn the procedures." A participant with self-reported moderate understanding realized what she needed to do to improve her understanding. She remarked,

> "I feel like I need to rework all my homework problems and figure out the ones I do not understand for test review day. Also, I think I need to meet up with my math group so we can all help and learn from each other."

Another participant with moderate anxiety realized, "With a lot of extra practice and help, I can reach my goal of understanding," whereas another with high anxiety simply stated, "I need to study more." By the end of the semester, participants reflected upon their overall experiences. One wished she had been "a little more proactive" in working with other students and meeting with the instructor during office hours. Another believed she "really worked hard to study for the test[s]….[and] stepped out of [her] comfort zone and chose [to] have study sessions with people in [her] class." Others discussed what they would do to help lessen their anxiety before the final exam. One said, "I hope that after reviewing these tests and understanding what I got wrong and why I did, I hopefully will do much better on the final exam." Another planned to "go in with a more positive attitude, study more, and try to decrease [her] amount of anxiety." Table 13 summarizes the assessment theme and provides exemplars for each group.

Table 13

Exemplars of student behaviors theme by group and anxiety level

Group	Anxiety Level	Exemplar
IBL	Low	"I go home daily and review what was taught in class. Also making notes so I can review the assignment for the test....Even when I get my test I go back and review what I did incorrectly so I can gather an understanding of what was did [*sic*] wrong."
	High	"I do not feel 'smart' at all while in math class….It's a subject that doesn't come natural to me."
Traditional	Low	"Helping other students understand the material has improved my confidence in my own abilities. Doing this reinforces that I really understand the material, rather than just learn the procedures."
	Moderate	"My anxiety for math never goes away because I am not and never have been a good math student and trying to cover everything in one class that I have never been able to understand before makes me really nervous and scared that I am going to miss something or forget a step and I will mess it all up."

CHAPTER V – DISCUSSION

Summary

The purpose of this mixed methods study was to determine the effect the instructional strategy used in a mathematics content course for preservice elementary teachers had on the students' math anxiety and achievement levels while considering descriptions of their experiences in the course in relation to their math anxiety and achievement. Two sections of the course were taught using traditional, lecture-style teaching methods, whereas the other two sections were taught using student-centered, IBL teaching methods. Quantitative data were obtained on math anxiety levels using the MARS-S and participants' self-reported anxiety levels from journal entries. Achievement levels were measured using pre- and post-tests of participants' content knowledge and participants' self-reported levels of understanding from journal entries. A variety of statistical tests, including two-way repeated measures ANOVA and *t*-tests were performed to test for differences within and between the traditional and IBL groups. Correlational analysis was performed to test for relationships between math anxiety and achievement. Qualitative data were obtained through participants' journal entries throughout the semester. Random samples of each journal entry were selected, and thematic analysis was performed. The common themes that were identified as impacting participants' anxiety and understanding of course material included course content, teaching methods, assessment, and student behaviors. The results of the quantitative analysis show how the instructional strategy impacted participants' math anxiety and achievement, whereas the results of the qualitative analysis highlight important insights into participants' thoughts and concerns regarding their anxiety and understanding of course material.

Conclusions

Conclusions are first presented for the quantitative analysis and then followed by conclusions for the qualitative analysis. Discussions related to the research questions and research hypotheses are included.

Quantitative Analysis

All quantitative analysis was performed using SPSS. The results of the statistical tests are discussed in relation to the research questions.

Research Question 1. As measured by the Mathematics Anxiety Scale Short Version (MARS-S), what effect do different instructional strategies have on preservice teachers' levels of math anxiety? Analysis revealed a statistically significant difference between the IBL and traditional groups in their initial MARS-S scores. The IBL group had significantly higher MARS-S scores than the traditional group. While the MARS-S scores decreased over the course of the semester for the IBL group and increased for the traditional group, the final MARS-S scores between the groups were not significantly different from each other. Furthermore, the initial and final MARS-S scores were significantly different for the IBL group and for the traditional group. The scores on the MARS-S for the IBL group decreased over the course of the semester, whereas the MARS-S scores for the traditional group increased.

Research Question 2. As measured by pre- and post-tests of preservice teachers' mathematical content knowledge, what effect do different instructional strategies have on preservice teachers' mathematics achievement? Statistical analysis indicated that the preand post-test scores of content knowledge increased over the course of the semester for both groups. A statistically significant difference in the pre- and post-test scores of the IBL group existed, a result similar to that of Lauren and Hassi (2012) who found that students in an IBL class experienced significant learning gains over the course of a semester. There was also a statistically significant difference in the pre- and post-test scores for the traditional group. However, there were not statistically significant differences between the pre- and post-test scores between the two groups.

Research Question 3. How do preservice teachers describe their experiences in Math 277 in regard to their math anxiety and mathematics achievement? Analysis of participants' self-reported levels of math anxiety from journal entries revealed statistically significant differences between the IBL and traditional groups for journal entries 1, 2, 5. In journal entries 1 and 2, which were collected at the beginning of the semester, the self-reported math anxiety levels of the IBL group were higher than the levels of the traditional group. However, by the time journal entry 5 was collected at the end of the semester, the self-reported math anxiety levels of the IBL group were lower than the traditional group. Furthermore, the self-reported anxiety levels within each group were analyzed. The IBL group experienced decreased levels of self-reported math anxiety as the semester progressed. There were significant differences between their self-reported levels of anxiety in journal entries 1 and 5 as well as journal entries 2 and 5. Their self-reported anxiety levels for journal entries 1 and 2 were each higher than their level for journal entry 5. On the other hand, the traditional group experienced increased levels of self-reported math anxiety as the semester progressed. There were significant differences in their self-reported anxiety levels between journal entries 1 and 5, journal entries 3 and 5, and journal entries 4 and 5. Self-reported anxiety levels for the traditional group were highest at the end of the semester in journal entry 5 but lowest in journal entry 1 at the beginning of the semester. Collectively considering participants' self-reported level of understanding, the level of understanding was lowest at the beginning of the semester with journal entry 2 (journal entry 1 did not assess their level of understanding). Self-reported level of understanding in journal entries 3, 4, and 5 were each significantly higher than that of journal entry 2.

Relationship Between Math Anxiety and Understanding. Correlational analysis that did not account for instructional strategy yielded several significant relationships between participants' math anxiety and understanding of course content. In journal entries 2, 3, 4 and 5, participants were asked to rate their levels of math anxiety and understanding of course content. There were statistically significant negative relationships between participants' self-reported levels of math anxiety and levels of understanding for each of the 4 journal entries. This indicated that as a participants' self-reported level of anxiety increased, then their self-reported levels of understanding decreased. A similar relationship between math anxiety and achievement was also found by Ashkraft (1991), Ashkraft and Krause (2007), and Wu et al. (2014). Also, a strong positive correlation existed between participants' initial and final MARS-S scores, indicating that higher MARS-S scores at the beginning of the semester corresponded with higher MARS-S scores at the end of the semester. A weak negative correlation was found between participants' final MARS-S scores and final content knowledge scores, which indicated that as final MARS-S scores increased, final content knowledge scores decreased. Participants' initial MARS-S scores and their self-reported level of math anxiety in journal 1 at the beginning of the semester had a statistically significant strong positive correlation. Furthermore, a statistically significant moderately positive correlation existed between the participants' final MARS-S scores and their self-reported level of math anxiety at the end of the semester in journal 5. This indicated that as participants' initial MARS-S scores increased, so did their self-reported level of math anxiety in journal 1. The same relationship held true for the final MARS-S scores and self-reported math anxiety at the end of the semester in journal 5.

Differences Between Instructional Strategies. Statistical analysis performed on final questionnaire results revealed many statistically significant relationships between the IBL and traditional groups regarding their opinions on classroom experiences and preferences in mathematics classrooms. A total of 14 statements were provided, and participants rated their level of agreement. Statistically significant differences were found between the IBL and traditional groups for 13 of the 14 statements with the IBL group scoring higher on 12 of the 14 statements. The statements in which the IBL group scored significantly higher are listed below.

- "I am likely to incorporate a similar instructional strategy in my own classroom."
- "I enjoyed the instructional strategies used in Math 277."
- "The instructional strategy used in this class has helped me be a better problem solver."
- "I learned more than I expected to learn."
- "I was intellectually challenged by the course."

- “The instructional strategy used in this class has encouraged me to find unique solutions to problems.”
- “Solving a problem using my own method helps me learn better.”
- “I felt motivated to work when I came to class.”
- “I am capable of learning new mathematics on my own.”
- “I have greater confidence in my mathematics skills now than before taking this course.”
- “I looked forward to coming to Math 277 class.”
- “This class was a positive experience for me.”

There was only one statement, “I prefer math classes in which the teacher uses traditional teaching methods,” in which the traditional group scored significantly higher than the IBL group. There was no statistically significant difference between the scores of the two groups regarding the statement, “I prefer to work with my peers in class rather than work independently.” For two of the aforementioned statements, similar results were found by Smith et al. (2009) and Alsup (2004). Smith et al. (2009) found that students who had taken IBL courses had increased self-confidence in their mathematics abilities and would use similar approaches in their own classroom. Participants in Alsup’s (2004) study also experienced more confidence in the mathematics skills after completing a constructivist-style course.

Qualitative Analysis

Qualitative analysis was performed by carefully reading through samples of participants’ journal entries and noting reoccurring themes. Data were then coded accordingly to these themes. A summary of the experiences of the preservice teachers in the IBL and traditional classes regarding their math anxiety and achievement is presented.

Research Question 3. How do preservice teachers describe their experiences in Math 277 in regard to their math anxiety and mathematics achievement? Four themes were identified in the participants' journal entries that affected their math anxiety and achievement. These themes included course content, teaching methods, assessment, and student behaviors.

Course Content.

Participants enrolled in the IBL group identified three areas of course content that affected their anxiety and understanding, whereas the traditional group identified 5 areas. Both groups reflected upon general course content, specific materials and models, and the conceptual nature of the course. Participants in the traditional group also identified the homework problems and amount of content as factors affecting their anxiety and understanding.

In both groups, participants experienced both increased and decreased levels of self-reported anxiety regarding general course content such as fractions, decimals, probability, or data analysis. Some participants were quite confident in their understanding of general course content, whereas others feared certain areas. There were no specific aspects of general course content in which all sampled participants in either group expressed either increased or decreased anxiety. These results were similar to those of Harper and Daane (1998) who also found that course content contributed to students' math anxiety. The same was true for specific materials and models presented in course content. Several students attributed higher levels of anxiety and lower levels of understanding to the use of pattern blocks and visual models, just as Vinson (2001) found in his study of preservice teachers but different from Harper and Daane (1998) who found that the use of manipulatives lowered preservice teachers' levels of math anxiety. Other participants believed the use of the pattern blocks and visual models improved their understanding of course content. In both the IBL and traditional groups, participants tended to attribute increased anxiety and lower understanding early in the semester to the conceptual nature of the course; however, by the end of the semester, participants in both groups reflected upon the conceptual nature in a positive manner stating that it contributed to increased understanding.

Even though the course content from the course problem set was identical for both the IBL and traditional groups, the format of the traditional classes resulted in their identifying the homework problems and amount of course content as additional factors affecting their anxiety and understanding. In the traditional classes, each section of problems in the course problem set was divided into in-class problems and homework problems. The course instructor led the class in discussions and solutions of the in-class problems, and the students were responsible for completing the homework problems prior to the next class. There was not a separation in the problems for the IBL classes; the students completed as many problems as they could during class time, and the remaining problems were to be done at home prior to the next class. Of the sampled participants who indicated the homework contributed to their increased levels of anxiety and lowered levels of understanding, they all stated that it was because the homework problems were different and more difficult than the in-class problems. Only two participants felt the homework problems reflected the in-class problems well. They both were confident in their understanding of course content and had low self-reported anxiety. Also, those participants in the traditional group who commented on how the amount of course content affected their anxiety believed there to be too much information to master and that the class meetings were rushed to cover all the material.

Teaching Methods

Several participants in the IBL classes attributed their anxiety and confusion of course material in the beginning of the semester the teaching methods. Participants believed they could not learn in an IBL classroom and were unsure how to solve the problems. Only one IBL participant was comfortable at the beginning of the semester about the way the class was structured, but as the semester progressed, more participants became accustomed to the teaching methods. This resulted in decreasing levels of self-reported math anxiety for many participants. Even though levels of anxiety and understanding varied among participants, in the final journal entries of the semester, there were no negative remarks about the teaching methods. Participants elaborated upon how the teaching methods aided them in understanding the course content instead of memorizing it and how beneficial facilitation in the classroom is to promoting understanding. Harper and Daane (1998) found similar results in that preservice teachers attributed lower anxiety levels to not having lectures and actively participating in class. IBL participants also had differing views on the student presentations of course content at the beginning and end of the semester. Early on, participants' anxiety levels increased because of the student presentations, but by the end of the semester, participants appreciated learning different ways to solve problems, gaining experience explaining their solutions in front of a classroom, and getting to know and work with their classmates on a daily basis.

While participants in the traditional group attributed their lower anxiety to the familiar lecture-style of the classes at the beginning of the semester, as the semester progressed, they had differing views. Several participants commented that their anxiety was increased because there was not enough time in class to review all the homework problems because the lecture portion of the class accounted for the majority of class time. In the final journal entry, one participant believed that the teaching methods were anxiety-inducing, whereas the majority liked the instructional strategy and believed it helped them understand the problems better.

Assessment

Participants in the IBL and traditional groups shared very similar thoughts regarding the effect of assessments on their anxiety. Many participants had elevated anxiety levels just prior to taking tests and immediately following tests as they awaited their grades. Sloan (2010) found a similar result in her study in that test anxiety contributed to students' math anxiety. Decreased anxiety regarding assessments was present in at least one participant in each group when they received their grades and realized they had scored well. Participants in each group also experienced anxiety because of their concern for their course grades and GPAs.

Student Behaviors

In both the IBL and traditional groups, there were several participants who attributed their anxiety early in the semester to their beliefs about their lack of ability to be successful in mathematics. However, participants employed certain strategies that helped lower their anxiety. In the IBL group, participants with decreased anxiety would take their time and persevere in solving problems, break down problems into smaller parts, watch videos, complete all assignments and problems, and review course content and tests regularly. Participants in the traditional group believed that in order to lower their anxiety, they had to spend a lot of time working on problems and studying, employ better study habits, relate the material to real life, and help others in their class learn the material. Student behaviors that participants in both groups attributed to increasing anxiety included overthinking problems and second-guessing themselves.

Research Hypotheses

Research questions 1 and 2 were investigated through statistical data analysis of the two research hypotheses. A discussion of each hypothesis follows.

Research Hypothesis 1. The preservice teachers who are enrolled in the courses with IBL as the instructional strategy will experience a significant decrease in their levels of math anxiety as compared to the preservice teachers who are enrolled in the courses with traditional teaching methods as the instructional strategy. Based on the MARS-S, the math anxiety levels of the IBL participants decreased over the course of the semester, whereas the math anxiety levels of the traditional participants increased over the course of the semester. While the final MARS-S scores at the end of the semester were not significantly different between the IBL and traditional participants, the IBL participants' initial and final MARS-S scores were significantly different from each other, as were the initial and final MARS-S scores for the traditional participants. Similar results were found for the participants' self-reported math anxiety levels from journal entries collected throughout the semester. In the beginning of the semester, IBL and traditional participants reported statistically significant differences in self-reported anxiety, with the IBL participants having higher anxiety levels. At the end of the semester, there were statistically significant differences between the IBL and traditional participants; however, the IBL participants had lower anxiety levels. Within each group of participants, there were also statistically significant differences in their self-reported math anxiety at the beginning and end of the semester. The self-reported math anxiety level of IBL participants decreased over the course of the semester, whereas it increased for traditional participants. These results differ from those of Alsup (2004) who found that students enrolled in a traditional, lecture-style course showed a larger decline in math anxiety than those in a constructivist, active-learning course. While Alsup's (2004) difference between the groups was not significant, a significant decrease in math anxiety scores from the beginning of the course to the end was found when the data were analyzed collectively.

Research Hypothesis 2. The preservice teachers who are enrolled in the courses with IBL as the instructional strategy will experience a significant increase in their achievement levels as compared to the preservice teachers who are enrolled in the courses with traditional teaching methods as the instructional strategy. While each group of participants experienced significant increases in achievement based on the results of pre- and post-tests, there was not a statistically significant difference in achievement between the IBL and traditional participants. These results differ from the meta-analysis of Freeman et al. (2014) who found that students enrolled in active-learning classes experienced higher achievement scores than those enrolled in lecture classes.

Limitations and Delimitations

There were several limitations and delimitations to the study. First, the study was delimited to only one course instructor for the four classes; thus, the results of the study may not generalize to other instructors. The study was limited to only preservice elementary school teachers who self-enrolled in the researcher's mathematics content course based on their scheduling needs. Student assignments to class sections were not random. The results of the study may not generalize to students with other college majors or those enrolled in other mathematics courses. This study was delimited to the assignments of the IBL and traditional groups. The researcher intentionally kept the classes that met on Mondays and Wednesdays the same format (randomly selected to be traditional), whereas the classes that met on Tuesdays and Thursdays were the same format (randomly selected to be IBL). The study was limited to primarily female students. Approximately 96% of the participants were female, so the results of the study may not generalize to classes in which the majority of the students are not female. The study was limited by its short time frame. The study was conducted over the course of one semester. The course in which the participants were enrolled is the second course in a three-course sequence. The study was limited by the honesty and clarity of the participants' responses on questionnaires, journal entries, and focus groups.

Recommendations for Practice

While the instructional strategy has no effect on student achievement and understanding of course material, students enrolled in classes being taught using traditional teaching methods experienced increased math anxiety, whereas those in IBL classes experienced decreased math anxiety and more positive opinions regarding their experiences and preferences in the mathematics classroom. Based on these results, it is recommended that instructors of mathematics content courses for preservice elementary teachers adopt student-centered, IBL techniques in their classrooms. For instructors who may be unfamiliar with IBL teaching methods, it is important that they participate in professional development opportunities focused on student-centered learning and conceptual understanding of mathematics. Furthermore, the results of the correlational analysis indicate a negative relationship between anxiety and student understanding. Course instructors and preservice elementary teachers should be aware of these findings so that appropriate help and suggestions can be provided to students to reduce anxiety before it negatively impacts their success in their mathematics courses. The results of the qualitative analysis indicate several ways in which preservice teachers can reduce their anxiety, including, but not limited to, having a positive attitude, persevering through problem solving, completing all assignments, consistently reviewing course content and assessments, and working with other students inside and outside of the class.

Recommendations for Future Research

Further research is needed to determine if the results from this study would generalize to students with different college majors or those enrolled in general education mathematics courses, such as College Algebra, Precalculus, or Elementary Statistics. Also, a longitudinal study following a cohort of preservice elementary teachers through the entire elementary education sequence of mathematics content courses taught using IBL methods could offer invaluable insight into their experiences and the impact of those experiences on their own teaching methods.

APPENDIX A – Mathematics Anxiety Rating Scale – Short Version

MATHEMATICS ANXIETY RATING SCALE SHORT VERSION (Suinn, 2003):

Items 1-30 in the questionnaire refer to things that may cause fear or apprehension. For each item, choose the option that describes how much you are frightened by it nowadays. Work quickly, but be sure to consider each item individually. Please note that 1 = not at all, 2 = a little, 3 = a fair amount, 4 = much, and 5 = very much.

		Not at all	A little	A fair amount	Much	Very Much
1.	Taking an examination (final) in a math course.	1	2	3	4	5
2.	Thinking about an upcoming math test one week before.	1	2	3	4	5
3.	Thinking about an upcoming math test one day before.	1	2	3	4	5
4.	Thinking about an upcoming math test one hour before.	1	2	3	4	5
5.	Thinking about an upcoming math test 5 minutes before.	1	2	3	4	5
6.	Waiting to get a math test returned in which you expected to do well.	1	2	3	4	5
7.	Receiving your final math grade at the end of the semester.*	1	2	3	4	5
8.	Realizing that you have to take a certain number of math classes to fulfill the requirements in your major.	1	2	3	4	5
9.	Being given a “pop” quiz in a math class.	1	2	3	4	5
10.	Studying for a math test.	1	2	3	4	5
11.	Taking the math section of a college entrance exam.	1	2	3	4	5
12.	Taking an examination (quiz) in a math course.	1	2	3	4	5
13.	Picking up the math text book to begin working on a homework assignment.	1	2	3	4	5
14.	Being given a homework assignment of many difficult problems, which is due the next class meeting.	1	2	3	4	5

15.	Getting ready to study for a math test.	1	2	3	4	5
16.	Dividing a five digit number by a two digit number in private with pencil and paper.	1	2	3	4	5
17.	Adding up 976 + 777 on paper.	1	2	3	4	5
18.	Reading a cash register receipt after your purchase.	1	2	3	4	5
19.	Figuring the sales tax on a purchase that costs more than $1.00.	1	2	3	4	5
20.	Figuring out your monthly budget.	1	2	3	4	5
21.	Being given a set of numerical problems involving addition to solve on paper.	1	2	3	4	5
22.	Having someone watch you as you total up a column of figures.	1	2	3	4	5
23.	Totaling up a dinner bill that you think overcharged you.	1	2	3	4	5
24.	Being responsible for collecting dues for an organization and keeping track of the amount.	1	2	3	4	5
25.	Studying for a driver's license test and memorizing the figures involved, such as the distances it takes to stop a car going at different speeds.	1	2	3	4	5
26.	Totaling up the dues received and the expenses of a club you belong to.	1	2	3	4	5
27.	Watching someone work with a calculator.	1	2	3	4	5
28.	Being given a set of division problems to solve.	1	2	3	4	5
29.	Being given a set of subtraction problems to solve.	1	2	3	4	5
30.	Being given a set of multiplication problems to solve.	1	2	3	4	5

*Edited from its original form by removing the phrase "in the mail."

APPENDIX B – Permission to use MARS-S

SOUTHEASTERN
LOUISIANA UNIVERSITY

Janelle Lorenzen <janelle.lorenzen@selu.edu>

Re: Request for MARS
1 message

RMS Suinn <suinn@lamar.colostate.edu> Mon, Jun 16, 2014 at 8:45 AM
To: Janelle Lorenzen <Janelle.Lorenzen@selu.edu>

The copies of the MARS short version is in today's mail.
Balance due is $10.50 for postage/handling. Pls let
me know when you receive the tests.

On Nov 24, 2012, at 8:28 PM, Janelle Lorenzen wrote:

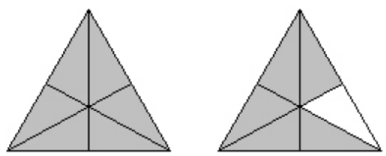
> Hello, Dr. Suinn. My name is Janelle Lorenzen, and I am a PhD candidate in mathematics education at the University of Southern Mississippi. My research area is math anxiety among preservice elementary teachers. I have read many articles that refer to the Mathematics Anxiety Rating Scale, but I have been unable to find a copy of the document. I plan on using it to assess before and after anxiety levels as part of my dissertation. Would you be able to send me a copy or point me in the right direction as to where I could obtain a copy?
>
> Thank you,
>
> Janelle Lorenzen
>
> --
> Janelle K. Lorenzen
> Instructor of Mathematics
> Southeastern Louisiana University

APPENDIX C – Assessment of Content Knowledge

Math 277 –Assessment of Content Knowledge   *Name:*   *W#:*

Instructions: Answer each question to the best of your ability on the provided answer form.

1. What fraction is represented by the shaded portion of the figure?



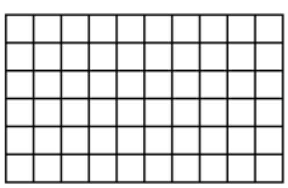
Unit = one large triangle

a) $\frac{5}{6}$ b) $\frac{11}{12}$ c) $\frac{11}{6}$ d) $\frac{5}{12}$ e) none

2. June wants to work for $15\frac{1}{4}$ hours at her part-time job this week. She has already worked $6\frac{1}{2}$ hours. How many more hours does she need to work?

a) $8\frac{3}{4}$ hours   b) $9\frac{3}{4}$ hours   c) $7\frac{3}{4}$ hours   d) 8 hours   e) none

3. How many small squares must be shaded to represent 35% of the large rectangle shown?



a) 15   b) 24   c) 27   d) 21   e) none

4. If 6 newborn babies are born at a hospital in one day, what is the probability that they are all girls?

a) $\frac{1}{2}$ b) $\frac{1}{7}$ c) $\frac{1}{36}$ d) $\frac{1}{64}$ e) none

5. Perform the operation and write the answer in scientific notation:
$0.00000234 \times 0.0000003674$

a) 8.60×10^{-12}
b) 0.860×10^{-13}
c) 8.60×10^{-13}
d) 8.60×10^{-14}
e) none

6. Rewrite “four hundred thirty-five ten-thousandths” as a numeral.

a) 0.00435 b) 435.010 c) 0.0435 d) 0.000435 e) none

7. George has $8\frac{1}{2}$ cups of fruit punch that he has made for a party. He has glasses that each hold $\frac{2}{3}$ cup of drink. If he fills as many glasses as possible, what fraction of the last cup will be filled?

a) $\frac{5}{6}$ b) $\frac{1}{2}$ c) $\frac{1}{3}$ d) $\frac{3}{4}$ e) none

8. Which fraction is represented by the following decimal? $1.181818\ldots$

a) $1\frac{19}{111}$ b) $1\frac{2}{11}$ c) $1\frac{13}{111}$ d) $1\frac{9}{11}$ e) none

9. A researcher collected data on the number of miles 100 people drove each week. His data values ranged from 10 miles to 725 miles. Which type of graph would best represent his data?

a) bar graph
b) line graph
c) histogram
d) stem and leaf plot
e) none

10. What type of correlation is likely to exist between the following variables: amount of time spent practicing guitar and the number of mistakes made when playing a song on the guitar

a) positive b) negative c) no correlation

11. Mr. Rivera opened a package of 150 drinking cups for his restaurant. During the day, 97 cups were used. Approximately what fraction of the package of cups was used?

a) $\frac{3}{5}$ b) $\frac{3}{4}$ c) $\frac{2}{3}$ d) $\frac{1}{2}$ e) none

12. Ray works as a waiter at a restaurant. His base pay from his hourly rate was \$325.79 last week. He had \$46 withheld for federal income tax, \$24.47 withheld for FICA tax, and \$11.40 withheld for other deductions. He also earned \$21.50 in tips. What is his net pay?

a) \$243.92 b) \$265.42 c) \$429.16 d) \$222.42 e) none

13. A card is drawn from a well-shuffled deck of 52 cards. What is the probability of drawing a face card or a 3?

a) $\frac{2}{13}$ b) 0 c) $\frac{12}{13}$ d) $\frac{4}{13}$ e) none

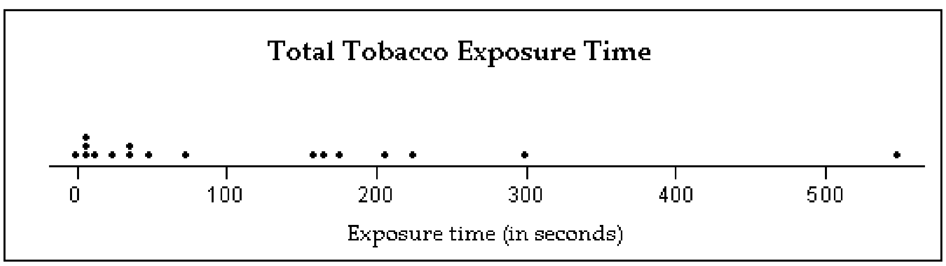
14. The size of a building can be measured many ways. Here are four examples: the floor area in square feet, the number of stories, the height of the building, and the number of rooms. What is true about these variables?

    a) Some are categorical and some are numerical.
    b) All are numerical and continuous.
    c) All are categorical and some are continuous and some are discrete.
    d) All are numerical and some are continuous and some are discrete.
    e) None

15. On a map of Fox River, 2 centimeters represents 5 kilometers. If a trail by the river is actually 22 kilometers long, what is the length of the river on the map?

    a) 6 cm   b) 8.8 cm   c) 8.5 cm   d) 12.8 cm   e) none

16. The article "Tobacco and Alcohol Use in G-Rated Children's Animated Films" investigated exposure to tobacco and alcohol use in all G-rated animated films released between 1937 and 1997 by five major film studios. The dot plot shows the total tobacco exposure time (in seconds) for one of the studios. Which measure would best describe the "center" of this data?



    a) mean deviation   b) median   c) mean   d) mode   e) none

17. Which bottle of juice is a better buy? 64 oz for $2.75 or 80 oz for $4.00

    a) 64 oz   b) 80 oz   c) they are the same

18. Consider the following data set: 2, 2, 3, 5, 8, 10. Which of the lists shows the measures in order from smallest to largest?

a) mode, mean, median, IQR, range
b) mode, IQR, median, mean, range
c) IQR, mode, mean, median, range
d) mode, median, mean, IQR, range
e) none

19. If it has been determined that the probability of an earthquake occurring on a certain day in a certain area is 0.01, what are the odds <u>against</u> the earthquake?

a) 99 to 1 b) 100 to 1 c) 1 to 100 d) 1 to 99 e) none

20. A box contains 3 white marbles, 2 green marbles, 2 red marbles, and 1 blue marble. If a green marble was chosen and not replaced, what is the probability that the second marble chosen will be blue?

a) $\frac{1}{28}$ b) $\frac{1}{7}$ c) $\frac{1}{8}$ d) $\frac{1}{32}$ e) none

APPENDIX D – Initial Questionnaire

The Effect of Instructional Strategies on Math Anxiety and Achievement: A Mixed Methods Study of Preservice Elementary Teachers

Thank you for taking the time to participate in this study. Findings from this study could be used to determine instructional strategies affect preservice elementary teachers' levels of math anxiety and achievement. These findings could lead to future research regarding math anxiety and achievement among various other groups of students. Furthermore, the results could be beneficial to educators and school leaders across multiple grade levels and institutions who are interested in reducing their students' levels of math anxiety while improving achievement. All responses will remain confidential.

Last Name: ______________________ W# ______________________.

DEMOGRAPHIC QUESTIONS: For questions 1 – 7, please indicate the response that best answers the question.

1. What is your class standing?
    - Freshman
    - Sophomore
    - Junior
    - Senior

2. What is your cumulative GPA?
    - Less than or equal to 1.0
    - 1.01 – 1.50
    - 1.51 – 2.00
    - 2.01 – 2.50
    - 2.51 – 3.00
    - 3.01 – 3.50
    - 3.51 – 4.00

3. What is your major?

    - Early Childhood Education (PK – 3)
    - Elementary Education (1 – 5)
    - Middle School Education (4 – 8)
    - Special Education (K – 8)
    - Other

4. If you are a middle school education major, what are your focus areas?

    - English
    - Math
    - Science
    - Social Studies

5. What was your final grade in Math 177 – Mathematics for Elementary Teachers I?
    - A
    - B
    - C

6. How many other classes during your college career have you previously taken that were delivered at least 75% in an inquiry-based learning format?
    - 0
    - 1
    - 2
    - 3
    - 4
    - 5 or more

7. In general, do you enjoy your mathematics classes?

    - Never
    - Rarely
    - Sometimes
    - Often
    - Always

<u>FREE RESPONSE ITEMS:</u> Please answer items 8 - 12 completely, while providing as much detail as you feel is necessary.

8. Describe how your prior college mathematics courses have been taught. Please consider both the roles of the teacher and students.

9. Describe your any comments or concerns you have regarding the instructional strategy that will be used in this section of Math 277.

10. Describe any positive opinions you have regarding the instructional strategy that will be used in this section of Math 277.

11. Describe any negative opinions you have regarding the instructional strategy that will be used in this section of Math 277.

12. How do you learn mathematics best?

APPENDIX E – Follow-up Questionnaire

The Effect of Instructional Strategies on Math Anxiety and Achievement: A Mixed Methods Study of Preservice Elementary Teachers

Thank you for taking the time to participate in this study. Findings from this study could be used to determine instructional strategies affect preservice elementary teachers' levels of math anxiety and achievement. These findings could lead to future research regarding math anxiety and achievement among various other groups of students. Furthermore, the results could be beneficial to educators and school leaders across multiple grade levels and institutions who are interested in reducing their students' levels of math anxiety while improving achievement. All responses will remain confidential.

Last Name: ______________________ W# ______________________.

DEMOGRAPHIC QUESTION: For question 1, please indicate the response that best answers the question.

13. What final grade do you anticipate earning in Math 277 – Mathematics for Elementary Teachers II?
    - o A
    - o B
    - o C
    - o D
    - o F

OPINIONS ON THE COURSE: For items 2-15, reflect upon your experiences in Math 277, and indicate to what extent you agree or disagree with the statement. Please note that 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree.

		SD	D	N	A	SA
2.	I am likely to incorporate a similar instructional strategy in my own classroom.	1	2	3	4	5
3.	I enjoyed the instructional strategies used in Math 277.	1	2	3	4	5
4.	I prefer math classes in which the teacher uses traditional teaching methods.	1	2	3	4	5

5.	I prefer to work with my peers in class rather than work independently.	1	2	3	4	5
6.	The instructional strategy used in this class has helped me be a better problem solver.	1	2	3	4	5
7.	I learned more than I expected to learn.	1	2	3	4	5
8.	I felt intellectually challenged by the course.	1	2	3	4	5
9.	The instructional strategy has encouraged me to find unique solutions to problems.	1	2	3	4	5
10.	Solving a problem using my own method helps me learn better.	1	2	3	4	5
11.	I felt motivated to work when I came to class.	1	2	3	4	5
12.	I am capable of learning new mathematics on my own.	1	2	3	4	5
13.	I have greater confidence in my mathematics skills than before taking this class.	1	2	3	4	5
14.	I looked forward to coming to Math 277 class.	1	2	3	4	5
15.	This class was a positive experience for me.	1	2	3	4	5

<u>OPINIONS ON THE COURSE:</u> Please answer items 16-20 completely, while providing as much detail as you feel is necessary.

16. What are your opinions about the instructional strategy that was used in this section of Math 277?

17. How do you think you performed in Math 277?

18. What about the instructional strategy used in Math 277 did you like the most?

19. What about the instructional strategy used in Math 277 did you like the least?

20. How do you learn mathematics best?

APPENDIX F – Focus Group Interview Guide

Objective:
To understand the experiences that students enrolled in Math 277 had in regard to their math anxiety and achievement based on the instructional strategy used over the course of the semester.

Introduction:
Good afternoon, and welcome to our session. Thanks for taking the time to join us to talk about your experiences in this course this semester.

(Introduce focus group moderator.)

I am interested in learning more about your experiences in this course in relation to the instructional strategy that was used by the course instructor and the effects this strategy had on your math anxiety and achievement in the course.
Please keep in mind that there are no wrong answers, although some may have differing points of view. Feel free to share your point of view even if it differs from what others have said. I am just as interested in negative comments as positive comments. With such a large group of students, it may be necessary to raise your hand in order to get my attention when you have something to add to the conversation.

This session will be tape recorded so that I don't miss any of your comments. The recording will only be used for the purpose of this study. Your instructor will not receive a copy of this session until after final grades have been posted.

Does anyone have any questions before we begin?

Interview Guide:

I'd like to start by talking about your general opinions about the instructional strategy used in this class.

1. Think back over the course of the semester. Tell us about some of the positive experiences you had.

2. Again, thinking back over the course of the semester, what were some of the negative experiences you had?

Thank you for your responses. I would like to talk now about math anxiety.

3. What have you experienced in terms of math anxiety?

4. Think about your math anxiety upon entering this course. Now that the semester is near the end, how would you say the instructional strategy used in this course lowered your level your math anxiety?
    a. Other than the instructional strategy, please tell us about any other factors that lowered your math anxiety.

5. For those of you who believe that the instructional strategy used in this course increased your level of math anxiety, please tell us how so.
    a. Please explain if there were factors other than instructional strategy that caused your math anxiety to increase.

Thanks again for your responses. Let's move on to your achievement in the course.

6. What have you experienced in terms of your achievement in the course?

7. How did the instructional strategy used in this course affect your understanding of the course material?
    a. How often would you say that you solved problems creatively using your own strategies?

    b. How often did you mimic the work of others – whether a classmate or the instructor?

8. What changes could be made to the course to improve your achievement?

Thanks again for your responses. I have just one final question before we end.

9. How has your experience in this course changed the way you view mathematics education?

Thank you again for your responses.

10. At this time, is there anything else that anyone would like to add that has not already been discussed?

I really appreciate your taking the time today to participate in this focus group. Thanks again for all of your help with this study

APPENDIX G – Journal Prompts

Week 1:

- Write your math autobiography. Discuss your feelings regarding mathematics and your experiences taking mathematics classes from kindergarten through college.
- Describe the benefits of understanding in mathematics in your own words and how you think understanding is different from memorizing.
- On a scale of 1 to 10, with 1 = none at all and 10 = extreme anxiety, what is your math anxiety level right now? Why?

Weeks 4, 7, 10, 13:

- On a scale of 1 to 10, with 1 = no anxiety at all and 10 = extreme anxiety, what is your math anxiety level right now? Why?
- On a scale of 1 to 10, with 1 = complete confusion and 10 = complete understanding, how would you rate your understanding of course material up to this point? Why?
- Identify skills or topics covered thus far with which you need additional practice.

Week 16:

- Write a reflection on your experiences in the course this semester. Some questions you <u>may</u> want to consider:
    - How do you feel about the instructional strategy used in this course?
    - Have your attitudes toward the instructional strategy changed?
    - Are you likely to incorporate this type of instructional strategy in your mathematics courses?
    - How has this course affected your math anxiety?
    - What is your level of understanding of the mathematical topics discussed in class?
    - How do you feel you performed in the class?
    - What would you do differently if you had to take this course again?

APPENDIX H – IRB Approval Letters

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI

INSTITUTIONAL REVIEW BOARD
118 College Drive #5147 | Hattiesburg, MS 39406-0001
Phone: 601.266.5997 | Fax: 601.266.4377 | www.usm.edu/research/institutional.review.board

NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Institutional Review Board in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: 15072802
PROJECT TITLE: The Effect of Instructional Strategies on Math Anxiety and Achievement: A Mixed Methods Study of Preservice Elementary Teachers
PROJECT TYPE: New Project
RESEARCHER(S): Janelle Lorenzen
COLLEGE/DIVISION: College of Science and Technology
DEPARTMENT: Center for Science and Mathematics Education
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Exempt Review Approval
PERIOD OF APPROVAL: 08/10/2015 to 08/09/2016
Lawrence A. Hosman, Ph.D.
Institutional Review Board

SOUTHEASTERN
LOUISIANA UNIVERSITY

Institutional Review Board
Box 11851
Phone: 549-2077

Campus Correspondence
www.selu.edu/irb
Fax: 549-3640

DATE: July 29, 2015

TO: Janelle Lorenzen
Mathematics

FROM: Dr. Michelle Hall, Chair

RE: IRB Action on Proposed Project

This memo is to inform you of the IRB action with regard to your proposal:

Title: The Effect of Instructional Strategies on Math Anxiety and Achievement: A Mixed Methods Study of Preservice Elementary Teachers

This proposal was given: Expedited Review:______

Full Committee Review: X

Exempt:______

The result was: Full Approval: X

Denied Approval:______

If anything other than Full Approval is recommended, it is your responsibility, as investigator, to submit changes/corrections or plans to accommodate conditions listed below to the Institutional Review Board prior to initiating the project. This approval is valid for one year from the date above, if data is to be collected after that time frame, the PI must submit a Continuation of Research Form.

Failure to acquire full approval by IRB before implementation for any project which involves humans means that the PI is not acting in "good faith" with university policy and is not, therefore, guaranteed the protection of the university.

Committee Comments:

IRB Number:2016-006

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