THE EFFECTS OF MOTIVATIONAL MESSAGES ON THE MATHEMATICS ANXIETY OF PRESERVICE ELEMENTARY EDUCATION MAJORS

by

Eric William Bryant

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

2023

THE EFFECTS OF MOTIVATIONAL MESSAGES ON THE MATHEMATICS ANXIETY

OF PRESERVICE ELEMENTARY EDUCATION MAJORS

By Eric William Bryant

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University, Lynchburg, VA

2023

APPROVED BY:

Jeff Rector, Ed.D., Committee Chair

Philip Alsup, Ed.D., Committee Member

ABSTRACT

This study examined the effects of motivational messages on the mathematics anxiety of preservice elementary education majors. A quantitative, quasi-experimental posttest nonequivalent control group design was used. The attention, relevance, confidence, and satisfaction model of motivation and control-value theories provided direction for this study. Sampling methods included convenience and voluntary response sampling of preservice elementary education majors in nine intact sections of required college mathematics courses. The number of participants sampled was 32. Participants in the treatment group watched supplemental videos embedded with motivational messages that covered concepts in the enrolled course. Participants in the control group watched supplemental videos without embedded motivational messages. All the participants completed a posttest of the Mathematics Anxiety Rating Scale-Revised. An independent samples *t*-test was used to test the null hypothesis that no significant difference emerged in the mathematics anxiety of preservice elementary education majors who viewed supplemental videos embedded with motivational messages and preservice elementary education majors who viewed videos without embedded motivational messages. The study found no significant difference between the control and treatment groups $t(30) = 0.21$, $p = 0.84$. Future empirical research should be conducted to include more participants, a longer time frame for the experiment, a more diverse population, a pretest and posttest design, a connection to mathematics achievement, and the placement of the experiment near the beginning of the required mathematics course as opposed to the end.

Keywords: mathematics anxiety, mathematics achievement, preservice elementary education majors, intervention

Dedication

This document is dedicated to two people with whom I share the closest of relationships. My Lord and Savior, Jesus Christ, came into my life when I was only a child. He has guided me throughout my life, even when I did not submit to Him. He demonstrated His love for me by sacrificing His life for me. My loving wife, Kimberly, came into my life through the providence of God. She continually demonstrated her unconditional love for me throughout the process of pursuing this degree. She willingly gave up some of our personal time so that I could complete this degree. Kimberly, I love you.

Acknowledgments

Many people have contributed to making this dissertation possible. I am especially thankful to Dr. Jeff Rector, the chairperson of my doctoral committee. He was patient, understanding, and meticulously demanding throughout the entire process. Dr. Philip Alsup served as a member of my committee. I am also grateful to my colleagues, Donna Marion, John Cuendet, Rochelle Achuff, Chris Bowman, Linda Williams, Ben Lane, Philip Holmes, Greg Lowhorn, and Phyllis Rand, who have been willing to answer my questions. I am blessed to serve with many other Christian teachers who love their Savior, colleagues, and students. We help each other strive for excellence for His glory.

I would also like to thank my children, who have helped me remember that this process is not the most important part of my life. Their periodic questions about my progress and their desire for a celebration were encouraging to me. It has been a joy to hear them finally call me "Dr. Dad."

Table of Contents

List of Tables

List of Figures

List of Abbreviations

Association of Christian Schools International (ACSI)

Attention Relevance Confidence Satisfaction (ARCS)

Mathematics Anxiety Rating Scale (MARS)

Mathematics Anxiety Rating Scale-Revised (MARS-R)

Mathematics Disability (MD)

Mathematics Learning Disability (MLD)

National Council of Teachers of Mathematics (NCTM)

National Science Foundation (NSF)

National Center for Education Statistics (NCES)

Science, Technology, Engineering, and Mathematics (STEM)

CHAPTER ONE: INTRODUCTION

Overview

Struggles in mathematics can be associated with a variety of factors. Researchers continue to examine why students perform differently at various stages of learning mathematics. This research has explored gender, ethnicity, socio-economic status, instructional design, education of parents, and training of teachers. Another key area of research has been the connection between mathematics and anxiety. The purpose of this study is to determine if an intervention on mathematics anxiety influences the mathematics anxiety of preservice elementary teachers. This chapter provides a background on mathematics anxiety, with special attention to definitions. The current literature is discussed, which leads to a gap in the literature that this research aims to fill. This chapter also lays the groundwork for this study by providing the problem and purpose statements. The chapter concludes with specific research questions, hypotheses, research variables, and definitions.

Background

Most people are embarrassed to admit that they cannot read, but people seem eager to admit they are weak in math (Wen, 2020; Zelkowski, 2010). In particular, many students avoid mathematics in daily life and even avoid taking higher mathematics courses when given the option (Chinn, 2009; Daker et al., 2021). Despite this disdain for or avoidance of math, mathematics is an essential aspect of daily life and has been shown to foretell individual and global success. Mathematics achievement has been shown to be a predictor of whether a student will actually receive a college degree (Adelman, 2006). Mathematics skills are sometimes evaluated for job opportunities (Duranczyk & Higbee, 2006). Mathematics also contributes to logical thinking skills that help in all the areas of life. As Galileo underscored, “The great book of nature can be read only by those who know the language in which it was written. And this language is mathematics" (Devlin, 2000, p. 152). Future scientists, engineers, and businesspeople require a strong background in mathematics along with confidence in their ability to use mathematics to ensure success in college and in their careers (Battista, 1999; Brunye et al., 2013).

Historical Overview

Examining the history of mathematics education in the United States is beneficial for the analysis of the problem of mathematics anxiety. Exploring the topic from the past helps uncover the continuing struggle to identify the best means of educating students. Part of the push for mathematics achievement in the United States came from the pressures of higher education and the results of war. In the late 19th century, universities in the United States were hiring teachers from other countries with established methods of mathematics instruction (Schubring, 2006). The Committee of Ten also instituted methods for instruction in various subjects, including mathematics (National Education Association, 1894). By the early 1900s, mathematics education had been established in classroom settings. The content covered generally came from agreed-upon topics that students would need to function in society. Mathematics education generally involved memorizing the rules of arithmetic and applying them to real-world examples. As various people fled Europe during World War I and World War II, they brought with them their beliefs about mathematics education. Further change occurred in mathematics education in 1950 with the establishment of the National Science Foundation (NSF). American soldiers serving alongside their European counterparts did not have the same mathematical capabilities. The prevailing concern was that mathematics education required students to speak and understand mathematical concepts abstractly (Schoenfeld, 2002).

The NSF established a government means of promoting higher standards in mathematics education. In 1957, the Russians' launch of Sputnik, the first artificial satellite, gave the American people the perception that the United States was lagging behind. A change was needed in the United States to produce the next generation of scientists who could keep up with the rest of the world. Hence, the "[development of] a modern mathematics curriculum was the reform tool chosen" (Walmsely, 2003, p. 3). The curriculum produced required teachers to rethink how they taught, having them focus less on rote learning and more on students understanding mathematical concepts (Walmsely, 2003, p. 4).

Another key group that influenced mathematics education was the National Council of Teachers for Mathematics (NCTM). The NCTM periodically publishes documents that promote a particular form of pedagogy and curriculum. The 1989 publication of *Curriculum and Evaluation Standards for School Mathematics* and the 2000 publication of *Principles and Standards for School Mathematics (Standards)* have called for more emphasis on the conceptual knowledge of mathematics (Schoenfeld, 2002). These documents have generally promoted a student-centered or discovery-based form of learning (Klein, 2007).

As these various agencies have been suggesting pedagogy and curriculum standards, researchers have been examining the mathematics anxiety of the students at various age levels. The idea of mathematics anxiety appears early in the literature with the research of Dreger and Aiken (1957) in which they analyzed college students' number anxiety. Richardson and Suinn (1972) continued to investigate the mathematics anxiety of people in a variety of situations and developed the Mathematics Anxiety Rating Scale (MARS). Various researchers have explored the role of gender (Alexander & Martray, 1989), context (Baloğlu & Zelhart, 2007), and age (Baloğlu & Zelhart, 2007; Hembree, 1990) in mathematics anxiety. Unfortunately, poor teaching practices have been found to influence mathematics anxiety and mathematics achievement (Hadley & Dorward, 2011). The reason behind examining mathematics anxiety relates to the link between mathematics anxiety and mathematics achievement. Researchers have found that a high level of mathematics anxiety reduces mathematics achievement (Ashcraft & Krause, 2007; Tobias, 1994). Furthermore, teachers play a role in the students' views of mathematics anxiety and competence (Aslan, 2013; Maloney & Beilock, 2012).

An interesting aspect of recent research has been the analysis of the age at which an individual is affected by mathematics anxiety. Wu et al. (2012) found that second and third graders had already started to exhibit mathematics anxiety. In fact, 20% of all students exhibit some level of mathematics anxiety (Ashcraft & Ridley, 2005). Thus, the issue of how a child could start exhibiting mathematics anxiety provokes research interest and merits an investigation. Many factors could play a role in this regard; however, a teacher's attitudes and pedagogy toward a subject influence the student's opinion and understanding (Jha, 2012). This inference points to a need for elementary teachers who have an attitude of excitement coupled with correct teaching techniques of mathematics. Students need teachers to approach all topics with enthusiasm; hence, this study attempts to determine if a teaching technique diminishes the mathematics anxiety that affects preservice teacher attitudes and pedagogy regarding mathematics.

Current technologies have allowed researchers to analyze the brain activity of math-anxious people. Lyons and Beilock (2012) examined the neural activity of individuals anticipating doing math in comparison to actually performing mathematics tasks. Functional magnetic resonance imaging was used for separating the neural activity. People who had a high level of mathematics anxiety showed an increase in regions of the brain, the posterior insula, which also serves to interpret physical pain even when they were simply anticipating the use of mathematics. This research specifically pointed to the anticipation of mathematics as the cause of mathematics anxiety. While performing mathematics tasks, the pain center in the brain was inactive. This aspect underscores the idea that interventions for mathematics anxiety should find ways to help preservice teachers manage their emotional responses before they have a chance to control mathematical ability (Lyons & Beilock, 2012).

Society at Large

A lack of confidence in mathematics stems from mathematics anxiety that is experienced by people with different backgrounds and ages (Ramirez et al., 2013). Mathematics anxiety contributes to the lack of mathematics achievement of some students (Ashcraft & Moore, 2009; Ma, 1999). Students avoid enrolling in mathematics courses or majors that require an extensive amount of mathematics due to mathematics anxiety (Ashcraft & Krause, 2007; Hembree, 1990). Beilock and Willingham (2014) contend that "an estimated 25% of four-year college students and up to 80% of community college students suffer from a moderate to high degree of math anxiety" (p. 29). This is significant to preservice elementary education teachers as they are preparing to teach. If preservice elementary education teachers avoid higher mathematics courses or have mathematics anxiety, then they have the potential for using poor methods and passing on their mathematics anxiety to their students (Platas, 2008). People who are mathematically anxious avoid tasks that require mathematics (Chang & Beilock, 2016). This avoidance by elementary teachers can influence the training of their own students in the field of mathematics (Jenßen et al., 2021). Studies are continuing to find that an elementary teacher's mathematics anxiety remains high even after preservice training (Gresham, 2018). Students who have teachers who are confident in their knowledge and portray this confidence to their students pass on this confidence to their students (Utley et al., 2005). Thus, research should identify certain methods for reducing mathematics anxiety in preservice elementary teachers.

In 2008, the United States National Mathematics Advisory Panel challenged researchers and educators to find interventions to the problem of mathematics anxiety with the hope of increasing mathematics achievement (U.S. Department of Education, 2008). This effort was not the first call for mathematics anxiety interventions; nonetheless, it did create a national awareness of the problem. Various interventions and theories have been proposed on how to reduce mathematics anxiety and, in turn, increase mathematics achievement. Haynes (2003) analyzed the effects of studying mathematics with background music on the mathematics anxiety and mathematics achievement of college algebra students. She found that although anxiety was reduced, mathematics achievement was unaffected. After examining the neural activity of highly math-anxious people, Lyons and Beilock (2012) suggested that classroom practices should find ways to help students control their negative emotions. Interestingly, Owens (1993) underlines the "theoretical or empirical connections between confidence in learning mathematics and students' achievement motivation, intrinsic motivation, self-concept, and self-esteem" (p. 26). To understand how affective characteristics in the pedagogy influence mathematics anxiety, Grouws and Cramer (1989) observed six junior high classrooms. The researchers found that the students enjoyed the classes and worked diligently for the teachers. The teacher interviews revealed that the teachers endeavored to develop relationships with the students, allow for cooperative learning, and share their past personal struggles with the concepts. These characteristics, in part, indicate the affective domain of mathematics. Schunk et al. (2008) suggest that effective classrooms provide students with positive feedback about their personal abilities to complete tasks.

Theoretical and Conceptual Background

Elementary teachers have the opportunity to influence the formative years of their students. An elementary teacher's enthusiastic rather than anxious approach to all topics should be expected. Unfortunately, mathematics anxiety is "an important barrier to success in math" (Ramirez, Shaw, et al., 2018, p. 145). Teachers with mathematics anxiety negatively influence the mathematics achievement of their students (Ramirez, Hooper, et al., 2018). The current study examines if Pekrun's control-value theory and Keller's ARCS model of motivation can help reduce mathematics anxiety.

Pekrun (2006) developed his control-value theory of emotions to explain how individuals' emotions influence the decisions they make. Various other theories, such as expectancy-value theory, attribution model, and affect control theory, contributed to Pekrun's development of his new theory of emotion (Zhang, 2022). Pekrun proposed control-value theory to analyze the antecedents of academic emotions. For the sake of his theory, Pekrun defined the aspects that are involved with emotions, stating, "Emotions are seen as multi-component, coordinated processes of psychological subsystems including affective, cognitive, motivational, expressive, and peripheral physiological processes" (Pekrun et al., 2006, p. 316). In other words, emotions are individuals' deeply complex reactions to perceived information or situations. Pekrun (2006) developed his theory because he did not find the research at the time to show how emotions are connected or how multiple emotions influence the decisions that people make. Meanwhile, Pekrun et al. (2006) aimed to find a system to explain how an individual's environment, perception of control, or connection to a task work together to influence an individual's decisions. Pekrun was specifically concerned about achievement emotions, which he defined as "emotions tied directly to achievement activities or achievement outcomes" (Pekrun, 2006, p. 317). When an individual takes a test, the activity would be the test and the outcome would be the earned grade. Other researchers have used this very theory either as a reference or for their actual theoretical framework to investigate preservice teacher training as it relates to mathematics (Goetz et al., 2013; Gresham, 2018; Jenßen et al., 2022; Wu et al., 2021). Pekrun (2021) suggests that the motivation of a teacher is a vital component of the learning process. The motivation provided by a teacher should convey “goals, wishes, and intentions related to performing actions and attaining desired states” (Pekrun, 2021, p. 313). An application of control-value theory could suggest that the motivational messages employed in the present study could increase the perceived value and perceived control. The increased value and control would allow students to increase their achievement emotions, cognitive strategies, behaviors, and continuing personal motivation.

The conceptual framework for the intervention of motivational messages to be applied in this study is based on the ARCS model of motivation. Motivational messages are messages of encouragement, empathy, and advice (Keller & Suzuki, 2004). They are generally positive messages that purportedly help people believe that, with sufficient effort, they can also complete a task. Keller (2010) developed this instructional model. ARCS is an acronym for attention, relevance, confidence, and satisfaction (Keller, 2010). Motivational design is defined as “the process of arranging resources and procedures to bring about changes in people’s motivation” (Keller, 2010, p. 22). Preservice teachers need to learn how to instill a sense of motivation to learn in their own students (Kiemer et al., 2015). Such teachers also need to have a high level of personal motivation and understanding of learning and pedagogy (Han & Yin, 2016). The ARCS model of motivation has been used in research that analyzes mathematics education because teachers need to not only instill motivation to learn but also cultivate their own motivation for learning and pedagogy (Hodges & Kim, 2013; Karakis et al., 2016). Teachers cannot be anxious regarding the content they teach or the pedagogy used in the classroom. In particular, preservice teachers without any motivation to learn give up too easily in their preparation for the classroom. They become focused on minimal work to complete the task of teaching instead of emphasizing what their students need from them. This incomplete classroom preparation results in poor explanations, which weakens their own students. Therefore, teachers should consider how to grab the attention of their students, keep the topics relevant, build confidence, and bring a sense of satisfaction to the learning process for themselves and their students. Visser and Keller (1990) used the ARCS model to create motivational messages for teachers to use in the classroom. They described the manner of creating these messages as “partly analytical and partly heuristic” (Visser & Keller, 1990, p. 486). Preservice teachers must learn how to define, design, develop, and evaluate the progression of their own students’ motivation to learn. This approach will create confidence for preservice and in-service teachers, which will in turn help their students. The ARCS model relates to the current study because it provides a technique for increasing preservice teachers’ motivation to learn mathematics despite any anxiety that they possess. A sample of the ARCS motivational messages planned to be embedded in the supplemental videos of this study is shown in Appendix A.

Problem Statement

The United States continues to lag behind other countries in terms of mathematics achievement. The 2019 Trends in International Mathematics and Science Study results revealed that although the mathematics achievement of eighth grade students in the United States has risen since 1995, the United States as a whole still performs at a lower level compared to countries such as Singapore, Chinese Taipei, South Korea, Japan, Hong Kong, Russia, Ireland, Lithuania, Israel, Australia, and Hungary (Mullis et al., 2021). Research has indicated that mathematics achievement is influenced by mathematics anxiety (Zhang et al., 2019). People who are math-anxious tend to select roles or responsibilities that do not include computational skills (Chinn, 2009). The students' view of mathematics, including their motivation to learn mathematics and their value of the concepts, affects their career choices in mathematics (Beilock & Maloney, 2015). Teachers represent one of the many aspects that influence student views on mathematics. Unfortunately, preservice elementary education majors may often come to college training with a disadvantage in training and tend to have more mathematics anxiety than other college students (Gonzalez-DeHass et al., 2017; Van der Sandt & O'Brien, 2017). Preservice elementary education majors who become teachers may tend to pass mathematics anxiety on to their students (Jha, 2012; Looney et al., 2017). Those who have mathematics anxiety may avoid teaching mathematical concepts that their peers without mathematics anxiety are routinely teaching. Constructs such as the conceptual understanding of mathematics may be diminished by mathematically anxious teachers (Lake & Kelly, 2014; Schaeffer et al., 2021).

Mathematics anxiety continues to be recognized as an issue for preservice elementary teachers; thus, researchers must continually identify ways to minimize the mathematics anxiety of preservice elementary teachers (Schanke, 2022). Peker (2009) found that when comparing preservice elementary and secondary teachers, elementary teachers exhibited higher mathematics anxiety. Preservice elementary teachers tend to have some of the lowest views of their own mathematical abilities (Burte et al., 2020). Preservice teachers express a "lack of confidence, ability, and mathematical content knowledge" (Gresham, 2021, p. 1). Researchers are still examining ways to help reduce the mathematics anxiety of preservice elementary education majors (Daker et al., 2021; Jenßen et al., 2021; Schanke, 2022). Elementary education majors have some of the highest levels of mathematics anxiety when compared to others with different majors (Gonzalez-DeHass et al., 2017; Van der Sandt & O'Brien, 2017). The problem is that preservice elementary teachers exhibit a high level of mathematics anxiety, and therapies should be found.

Purpose Statement

The purpose of this quasi-experimental posttest nonequivalent control group design is to test Pekrun's control-value theory and Keller's ARCS model of motivation theory as they relate to preservice elementary education majors' mathematics anxiety. This research seeks to analyze the effects of an intervention on the mathematics anxiety of preservice elementary teachers. This population is being examined because their views and understandings of mathematics have an impact on students (Schaeffer et al., 2021). Motivational messages as the independent variable are defined as messages of encouragement, empathy, and advice offered by a person of authority or influence (Keller & Suzuki, 2004). The positive messages are intended to help a person believe that with sufficient effort, the task can be successfully completed. The independent variable comprises two levels: exposure to motivational messages in supplemental videos and non-exposure to motivational messages in supplemental videos. The videos are being used out of convenience instead of the intent to change the lecture content for the college course. Multiple videos created by the researcher correlate to topics taught in a mathematics course for preservice elementary education majors. Each video will be approximately five minutes in length and will include the researcher demonstrating how to complete mathematical problems that correlate to the mathematical problems already presented by the participant's professor. However, the researcher will not be the participant's professor. The researcher will use words of encouragement, empathy, and advice as he completes the mathematical problems within the videos. The dependent variable of mathematics anxiety "involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 555).

Significance of the Study

Elementary teachers have been studied with respect to their mathematics anxiety and their students' mathematics achievement (Beilock et al., 2010; Hadley & Dorward, 2011); however, calls to find interventions to help students at all levels reduce mathematics anxiety and increase mathematics achievement continue to be made (Beilock & Willingham, 2014; Gresham, 2021; U.S. Department of Education, 2008). The results of the current study may provide support for an intervention that can assist preservice teachers in reducing math anxiety and improving mathematics achievement. As such, teacher education programs may use these findings to change how they prepare preservice elementary teachers to adjust the curriculum and how math is taught. Special courses designed based upon the intervention examined in this study could be created to help diminish mathematics anxiety and increase mathematics achievement for this population. Elementary education majors take methods courses in various subject areas. The mathematics methods course could include discussions and interventions regarding mathematics anxiety. The skills learned by preservice teachers for recognizing and minimizing mathematics anxiety could be implemented in classrooms. Second, preservice elementary education majors may learn to minimize mathematics anxiety and thereby avoid passing on the feelings of mathematics anxiety to students. In the site for the study, specific training programs may be developed to help detect and reduce mathematics anxiety in the overall student population. Finally, this study will add to the empirical literature by identifying a means of helping students reduce mathematics anxiety and by answering the call by the National Mathematics Advisory

Panel to improve the mathematics achievement of students (U.S. Department of Education, 2008).

Research Question

The following research question is addressed in this study:

RQ1: Does a significant difference exist in the mathematics anxiety of preservice elementary education majors who view supplemental videos embedded with motivational messages and preservice elementary education majors who view videos without embedded motivational messages?

Definitions

1. *Mathematics anxiety* – It "involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 555).
2. *Mathematics Anxiety Rating Scale-Revised (MARS-R)* – This anxiety rating scale is similar to the original MARS developed by Richardson and Suinn (1972). The original test comprises 98 items that are rated on a Likert scale. This shortened version created by Alexander and Martray (1989) consists of only 25 items.
3. *Motivational messages* – They pertain to positive messages of encouragement, empathy, and advice that people use to encourage themselves through adequate personal effort to complete a task (Keller & Suzuki, 2004).

CHAPTER TWO: REVIEW OF THE LITERATURE

Overview

The aim of this chapter is to help readers improve their understanding of the factors involved with mathematics anxiety and mathematics achievement. Various theories that have contributed to the study of these two constructs are also discussed. Special attention is given to control-value theory and the ARCS model of motivation to guide the whole purpose of this research. As this study focuses on mathematics, the examination of the history of mathematics education, including teaching techniques, is appropriate. A wide variety of studies and some interventions for mathematics anxiety are also explored.

Theoretical Framework

Mathematics is an essential part of life, which helps people who understand it to not only gain knowledge for daily living but also cultivate the ability to think and reason rigorously. Unfortunately, many students avoid mathematics in daily life and even avoid taking higher mathematics courses when given the option (Chinn, 2009; Choe et al., 2019). This situation leads to a weakness in mathematics competence for society, creating difficulty in competing globally (Battista, 1999; Brunye et al., 2013). Most students have a desire to receive the best grade possible in the subjects they study, despite a sense of apprehension when beginning something new, such as the work on a dissertation. However, most of the subjects studied rarely strike fear or induce a willingness to accept low achievement, more so than mathematics. Hearing people admit that they are not good at math, fear math, or even hate math is rather commonplace (Bethune, 2013; Schwartz, 2020).

ARCS Model of Motivation

An affective intervention is considered for this research because of the affective links mentioned in the literature. Theories of motivation create the foundation for the theoretical framework of this study. The Attention Relevance Confidence Satisfaction (ARCS) model was developed by John Keller as a way to use motivation in instructional settings (Keller, 1987). When some teachers present concepts, they view what they do as providing information to students and allowing the students to decide their own level of interest in and motivation for the subject matter. A teacher has the ability to also influence the level of motivation and thereby interest in the subject through various methods (Keller, 1987). The idea is that some students simply choose to give up if the topic fails to grab their attention, seems irrelevant, creates a lack of confidence in ability, or does not bring any satisfaction to the learner. Visser and Keller (1990) have validated this model, even showing that it impacted student performance. They found that the messages created using the ARCS model provide teachers with a positive way of affecting a student's motivation to learn. However, the model is not designed to teach a student how to be self-motivated (Keller, 1987, p. 6).

The ARCS model is essentially a synthesis of various theories of motivation. The objective of motivational theories is to explore the means of gaining a learner's attention, establish the relevance of the concepts to the learner, build confidence in the expectations and cultivate personal responsibility, and determine ways to help the instruction seem satisfying to the learner (Keller, 1987). According to expectancy-value theory, individuals will participate in an activity (i.e., learning in a classroom) if there is a reasonable expectation that the activity will provide them with some value (Wigfield & Eccles, 2000). Interestingly, Wigfield and Eccles with their expectancy-value theory and Keller with his ARCS model have all examined how students perceive and persist in the study of mathematics (Keller & Suzuki, 2004; Wigfield & Eccles, 2000).

Keller (1987) expands on expectancy-value theory with his ARCS model to create instructional design methods; hence, it is best suited to explain the thinking behind the use of motivational messages as an intervention in the current study. Attention, as conceived by Keller (1987), is easy for teachers to obtain from their students, but it can be difficult to maintain within the students. Keller suggests that teachers keep the students' attention using conflict, concreteness, variability, humor, inquiry, and participation (p. 4). When a teacher creates a conflict of facts, the students are compelled to think along with the teacher by judging the facts to resolve the conflict. Teachers who make lessons concrete through visuals, examples, or stories relate what may be abstract to the lives of the students. When teachers vary their communication style with their voice and body or perhaps change the instructional format from lecture to discussion, the students are kept guessing what could happen next. A teacher who uses humor breaks up the monotony of being greatly serious, thereby keeping the attention of the students. Including questions in a lecture allows students to participate and a teacher to evaluate student knowledge. A teacher should create a classroom culture by inviting students to ask questions based on their interest in the topic. This approach will also foster participation in the class. Of course, participation should not be limited to just questions. Teachers can keep the attention of students by having them act out parts of a history lesson or involving them in games (Keller, 1987, p. 4).

Keller's thinking about relevance as part of the ARCS model is addressing the concern of students that they may never use the content they are learning. Why should they really care about a mathematics fact? What is the significance to life that they learn how to keyboard or memorize historical facts? Teachers need to relate the content to the life experiences of the students. This approach requires the teacher to determine the topics that interest the students and to make purposeful connections to careers or decision-making. A teacher could easily show the relevance of content by simply stating its value, providing opportunities for success in a trusting environment, inviting guest speakers on topics, displaying enthusiasm, or possibly allowing students to make some choices on the topics they believe are valuable to research for topics (Keller, 1987, p. 4).

Individuals who lack confidence in a skill can potentially limit themselves. On the contrary, people with strong confidence trust in their abilities and accept more challenges. A confident person will continue to try despite the potential for mistakes, whereas someone driven by fear will be hesitant to try. Keller (1987) believes that “fear of failure is often stronger in students than teachers realize” (p. 5). This fear or anxiety is a demotivating factor. Teachers should explain the outcomes to students, instruct them on how to set personal goals and evaluate themselves, plan the level of difficulty to start small and grow, associate successes with hard work, and encourage self-confidence based upon independent workers who acknowledge mistakes as opportunities to learn (Keller, 1987, p. 5).

Keller (1987) asserts that students who are personally satisfied with the work they have completed will have a sense of control over outcomes. Teachers who create a perception in the minds of the students that only the teacher has the ability to reward good work will diminish the students’ belief that they have the ability to gain a personal, intangible reward. Teachers must provide opportunities for students to take ownership of learning and thereby obtain personal satisfaction. Keller (1987) suggests that teachers can achieve this goal by giving students opportunities for applying knowledge, providing praise for accomplishments, allowing students to tutor students, offering unexpected rewards, remaining positive even in struggles, and creating the opportunity for self-evaluation (p. 5).

The ARCS motivational design model requires that a teacher define, design, develop, and evaluate the progression of an individual's motivation to learn (Keller, 1987, p. 6). In the definition phase, the instructor examines the current motivational problem in a course of study and ascertains how the student is currently motivated to learn about the problem. Moreover, the instructor determines the outcomes to be accomplished by the student. In the design phase, the instructor formulates various methods to help the student become motivated about a course and achieve its outcomes. The development phase requires the instructor to literally develop the methods and implement them into the instruction. Verifying whether the outcomes have been attained is necessary; hence, the final phase of evaluation provides the instructor with the opportunity to examine if the motivational outcomes have been achieved (Keller, 1987, p. 7).

The ARCS model provides teachers with a strategy for assessing a student's motivation to learn and establishing a plan to boost such motivation to learn. Employing such a strategy offers teachers some consistency in how students might respond. This model has been used for improving student motivation for various age levels and topics such as foreign language acquisition (Chang & Lehman, 2013), mathematics (Hodges & Kim, 2013), curriculum design (McConnell et al., 2001), technology (Yao, 2008), and distance education (Huett et al., 2008).

Motivational messages created through the ARCS model and used in research constitute messages of encouragement, empathy, and advice (Keller & Suzuki, 2004). A teacher might use phrases such as "You did a great job," "I know you can do this," "I noticed that you tried a new technique that works," "I understand this activity is frustrating right now, but keep trying," "We can do this together," or "This is a common mistake that can be overcome with practice."

Notably, Keller is not the first researcher to explore the idea of learner motivation. Keller's work builds upon the thinking of control-value theory. Other researchers have also analyzed a student's motivation to learn and the consequences of that motivation.

Control-Value Theory

Another theory that has recently emerged examines the links between a student's achievement emotions and achievement performance. This theory is particularly relevant to the current study because of the emotion of anxiety that some people express when approaching mathematics. Pekrun (2000) first developed control-value theory at the University of Munich. According to control-value theory, achievement emotions "influence cognitive resources, motivation, use of strategies, and self-regulation vs. external regulation of learning" (Pekrun et al., 2007, p. 16). The theory essentially examines how individuals' perspective on control over a situation and the value of that situation could affect their emotions, behaviors, and academic outcomes. If people anticipate they have control over their own success in a task through effort on their part and their effort will lead to a positive outcome, then they become more willing to try that task. Students who do not believe they have control over their assigned task may make the judgment that making any attempt is not worthwhile. Students who also anticipate the shame of not completing the task may make a judgment call that making an effort is not worthy. "If perceived control is high and the focus is on success, anticipatory joy is assumed to be instigated" (Pekrun et al., 2007, p. 19). Students who know that memorized facts will predict a good grade will anticipate joy. In fact, "Hope will be instigated if the focus is on success, and anxiety if the focus is on failure" (Pekrun et al., 2007, p. 19). Another possibility is to trigger mixed emotions from students who hope for success in a task while simultaneously fearing failure. In some cases, the idea that failure is expected may be so obvious to students that they simply give up. Having hope or anxiety is unnecessary if failure is this certain.

Control-value theory describes achievement emotions as those emotions that a person experiences when achieving or not achieving certain goals (Pekrun et al., 2007, p. 15). Achievement emotions are classified into three types, namely prospective outcome emotions, retrospective emotions, and activity emotions. Prospective outcome emotions include joy, hope, hopelessness, relief, and anxiety. If people anticipate failure with low control over a situation, then they will feel a sense of hopelessness. If these same individuals believe that they will fail the task but have control over the situation, then they will anticipate relief when the task is complete. Retrospective emotions pertain to emotions that look back on past successes and failures. People feel joy, pride, gratitude, sadness, shame, and anger about past experiences depending on their perception of success, failure, or control over a situation. Students who failed a test will be angry if they place blame on another person for that failure. They may also feel gratitude for another if the success is attached to another individual. Emotions associated with activities are not necessarily tied to attaining certain outcomes. These achievement emotions can also be categorized as activity emotions. These emotions are enjoyment, anger, frustration, and boredom. A person completing a perceived positive task with high control would experience enjoyment. An athlete enjoys exercising for the sake of exercising. This task, which they control, can bring them enjoyment. However, a monotonous task will be perceived as boring, whether the person has low or even high control over the task. Control-value theory describes a situation in which achievement emotions influence how and even if knowledge is obtained (Pekrun & Linnenbrink-Garcia, 2014).

These two theories indeed indicate that emotions play a significant role in the classroom. In terms of anxiety, teachers need to constantly consider the means of motivating students, provide them with a level of control, and find ways to help students value the content of the classroom. These two theories explain the rationale for and a strategy to consider in analyzing mathematics anxiety. Control-value theory helps to explain why anxiety could be occurring in students. The ARCS model provides methods that could be used for increasing the perception of control and potentially reducing anxiety.

Related Literature

Training Elementary Teachers

Elementary teachers teach foundational content knowledge needed later in education and life. They also help students develop learning strategies and an understanding of learning that they will use throughout their lives (Browning et al., 2014, p. 333). The study of mathematics assists in the development of critical thinking skills through carefully crafted word problems and class discussions of mathematical applications. This critical thinking must begin in the elementary classroom (Aizikovitsh-Udi & Cheng, 2015, p. 466). The responsibility that elementary teachers assume involves a serious examination of every aspect of learning. This examination reveals the pressure for quality education.

History of Mathematics Education

An effective elementary teacher should appreciate the various changes that mathematics education has undergone. Learning lessons from the past helps current teachers understand current practices. Much of the history of mathematics education in the United States shows an emphasis on rote memorization and application to real-life scenarios in K–12 mathematics. Universities started requiring higher-level mathematics knowledge before a high school graduate would be accepted. A change in thinking occurred among universities in the United States. These universities were hiring professors from other countries, getting pressure from the science community that U.S. citizens should be better at mathematics, and struggling in the race to space (Schubring, 2006). The establishment of the National Science Foundation (NSF) in 1950 firmly helped to resolve the concern that United States citizens should be able to speak and understand mathematical concepts abstractly. The curriculum produced required teachers to rethink how they taught. The new curriculum chose "to abandon rote learning and teach with a more logical approach to mathematics where students could understand mathematics" (Walmsely, 2003, p. 4). At the same time, "Calculator use was encouraged to excess and integrated even into kindergarten lessons" (Klein, 2007, p. 25). In addition, "Some of the widely used programs aligned to the *Standards* did not even include textbooks, since books might interfere with student discovery" (Klein, 2007, p. 25).

Math Wars

A debate within educational circles subsequently ensued, specifically between groups of mathematics teachers who preferred a more traditional approach to education and those teachers who favored a reformed approach to education. The debate continues as the National Council of Teachers for Mathematics (NCTM) periodically publishes documents that promote a standards- or a reform-based form of instruction. The 1989 publication of *Curriculum and Evaluation Standards for School Mathematics* and the 2000 publication of *Principles and Standards for School Mathematics (Standards)* have called for more emphasis on conceptual knowledge of mathematics (Schoenfeld, 2002). The debate over the type of mathematics curriculum did not stop at mathematics or even in the world of education. In fact, "The *Standards* reinforced the general themes of progressive education by advocating student centered, discovery learning" (Klein, 2007, p. 23).

History of Mathematics Anxiety

The idea of mathematics anxiety is distinctly found in the literature, even as far back as the 1950s. In 1954, after a 25-year career teaching mathematics from elementary to college, Sister Mary Gough wrote about a condition that she called "mathemaphobia" (Gough, 1954). Gough created this term to help explain all the struggles that some students experienced with mathematics. She believed that these struggles were "almost as common as the common cold" (Gough, 1954, p. 290). Gough observed that students developed mathemaphobia via their failure to see math connections to the real world or through interactions with impatient teachers who refused to help struggling students. These students typically asked to be removed from higher mathematics courses and, when given the options after high school, avoided mathematics altogether (Gough, 1954). Gough called for researchers to investigate this issue to understand its causes and potential cures. More than 60 years later, the research continues, resulting in name changes, refined definitions, descriptions of symptoms, and potential cures. Researchers still struggle with exploring and ascertaining the causes of this condition (Baloglu & Kocak, 2006; Devine et al., 2012).

The mathemaphobia that Gough (1954) wrote about has become known as number anxiety (Dreger & Aiken, 1957), mathematics attitudes (Neale, 1969), and mathematics anxiety (Richardson & Suinn, 1972). In their research on 704 undergraduate students to determine the levels of emotion surrounding mathematics, Dreger and Aiken (1957) used the term "number anxiety." Their research represented the first attempt to show that mathematics presented its own type of anxiety (Dreger & Aiken, 1957). Number anxiety pertains to "a syndrome of emotional reactions to arithmetic and mathematics" (Dreger & Aiken, 1957, p. 344). The research underscored that a person's intelligence does not influence number anxiety, but number anxiety does influence mathematics performance.

One of the first instances that "mathematics anxiety" appears in the literature occurred with the research completed by Richardson and Suinn (1972). The goal of the research was to develop a tool for measuring mathematics anxiety levels. The Mathematics Anxiety Rating Scale (MARS) was developed by using 143 participants to evaluate the effectiveness of the 98-item questionnaire. The participants were to individually record their level of anxiety from 1 to 5, with 1 signifying "not at all" anxious and 5 denoting "very much" anxious. The 98 questions related mathematics to practical situations such as budgeting and taxes. The researchers found that the MARS showed a two-week test–retest reliability of .78. The mathematics portion of the Differential Aptitude Test (DAT) was given to analyze the impact of anxiety on performance. Higher anxiety was found to produce lower mathematics scores on the DAT. Twenty-four participants in the study were identified as having mathematics anxiety (Richardson & Suinn, 1972).

This research continues to be important because difficulties in mathematics are a problem that many people continually experience, and finding ways to diminish such concerns is necessary (Vukovic et al., 2013). This requisite is even more imperative now to develop qualified individuals in the areas of science, technology, engineering, and mathematics (STEM) (Núñez-Peña et al., 2013). Unfortunately, "nothing specific has been done to address the issues raised for the general population" (Flegg et al., 2013, p. 5). Although math is needed for any individual to function in society, whether pursuing a career in the areas of STEM, some people simply do not enjoy studying and using mathematics (Vukovic et al., 2013).

Researchers have investigated the various reasons for mathematics anxiety. People's views of their own mathematical abilities have an impact on their mathematics anxiety (Frenzel et al., 2007). Furthermore, the mathematics anxiety of individuals influences their mathematical abilities (Pekrun et al., 2006). Some researchers are starting to suggest interventions to minimize mathematics anxiety and thereby increase mathematics achievement. For instance, Ramirez and Beilock (2011) made students write about any anxiety they had before taking a mathematics exam. The researchers found that exam scores increased by nearly 10% by using this simple intervention (Ramirez & Beilock, 2011, p. 211).

An exploration of the literature for mathematics anxiety shows that the literature makes connections to mathematics disabilities, which occur about 6%–14% of the time in children (Barbaresi et al., 2005, p. 288). Students may exhibit various types of learning disabilities. The National Center for Educational Statistics reported that during school year 2017–2018, about 14% of all kindergarten through 12th grade students in the United States had a disability. Approximately 33% of these students had a learning disability (National Center for Education Statistics, 2020). Mathematics disability (MD) or mathematics learning disability (MLD) does not have a universally accepted definition (Mazzocco & Myers, 2003). Mazzocco and Myers (2003) also identify different sub-types of MD that relate to the recall of math facts, math procedures, and the understanding of visual math symbols. The term dyscalculia refers to "a wide range of life-long learning disabilities involving math. There is no single form of math disability, and difficulties vary from person to person and affect people differently in school and throughout life" (Disabilities, 2006). Dyscalculia is a "widely under-diagnosed learning disability" (Wolkowicz, 2011). Individuals with dyscalculia struggle with basic math concepts, mathematics accuracy, and reasoning skills (Frye, 2020; Wolkowicz, 2011).

People of various ages exhibit mathematics disabilities in different ways. For instance, a preschool and kindergarten child might have difficulty sorting, counting, or associating written numbers with the concept of a number. A lower elementary student might struggle with the sizes of numbers, anxiety, problem solving, and even finger counting. An upper elementary and middle school student might struggle with accuracy, multiple-step problems, application of math outside the classroom, and anxiety. High school students struggle with measurements, graphs, estimation, applications, and anxiety (Soares et al., 2018, pp. 52-53).

The literature reveals that mathematical learning disabilities are connected to math anxiety beginning in lower elementary (Soares et al., 2018, p. 52). Ashcraft and Moore (2009) indicate that “mathematics anxiety is a person’s negative affective reaction to situations involving numbers, math, and mathematics calculations” (p. 197). Ashcraft and Moore (2009) suggest that “it is likely that a student’s math anxiety is aroused in the math classroom itself, possibly only to a minor degree during routine class activities but almost certainly when the student is called on to answer a question or solve a problem” (p. 204). Legg and Locker (2009) define mathematics anxiety as “a general fear or tension associated with anxiety-provoking situations that involve interaction with math” (p. 471). Another study reported “a close relationship between math anxiety and math ability on evaluation of mathematics in primary school children” (Krinzinger et al., 2009, p. 223).

As teachers are on the frontline when teaching children mathematics, knowing their view or perspective is important. “If people who are anxious about math are charged with teaching others mathematics—as is often the case for elementary school teachers—teachers’ anxieties could have consequences for students’ math achievement” (Beilock et al., 2010, p. 1860). In their research, Gagnon and Maccini (2007) surveyed a random sample of all general educators and all special educators of public high school teachers in the United States. The researchers sought to determine a teacher's definition of math, familiarity with secondary course topics, perception of undergraduate special and general methods courses as preparation for teaching, and perception of preparation to use a variety of instructional strategies (Gagnon & Maccini, 2007, pp. 45-46). The initial sample included 325 general educators and 425 special educators. After receiving the mailings, 76 general educators and 91 special educators responded (Gagnon & Maccini, 2007, p. 46). The survey questions were sent to the teachers. A different set of questions was sent to the general educators in comparison to the special educators. The researchers left the question of a definition of mathematics as an open-ended query. The results of the research revealed a variety of answers for the definition of mathematics. The most common definition given by the sample of special and general educators was that math was "a necessary tool" (Gagnon & Maccini, 2007, p. 48). Teachers also defined mathematics as "a language" and a necessary tool for "think[ing] logically" (Gagnon & Maccini, 2007, p. 48).

Mathematics Anxiety Symptoms

Mathematics anxiety affects people in a variety of ways. According to Akin and Kurbanoglu (2011), people can exhibit feelings of tension, doubt, despair, nausea, palms sweating, and difficulty in breathing (p. 264). Mathematically anxious people have more feelings of "tension, frustration, distress, helplessness, and mental disorganization," especially when completing mathematics-related tasks (Ma & Xu, 2004, p. 165). The feelings of anxiety force students to avoid higher mathematics or tasks requiring mathematics (Brunye et al., 2013; Chinn, 2009). Passolunghi et al. (2016) agree that mathematics anxiety produces "a feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of math problems in a wide variety of ordinary life and academic situations" (p. 1). Additionally, math anxiety "is a primary impediment to student success in both STEM coursework and careers" (Brunye et al., 2013, p. 6). Widjajanti et al. (2020) conclude that mathematically anxious people experience "low self-confidence, negative thinking patterns towards learning mathematics, feeling threatened, failing to reach potential, and quickly forgetting with mathematical formulas" (p. 1). Pletzer et al. (2015) found evidence that a difference exists in the neural efficiency of people with mathematics anxiety. Bekdemir (2010) defines mathematics anxiety as "an illogical feeling of panic, embarrassment, flurry, avoidance, failing and fear, which are physically visible, and which prevent solution, learning, and success about mathematics" (p. 312). Gresham (2018) documented the symptoms and results of teachers' own mathematics anxiety both before and after becoming teachers.

> Before
>
> When I hear the word math, I cringe! I hate it! I hate it! I hate it! And the sad thing is I know that my students are going to pick up on that fact. How in the world will I ever be able to be a good math teacher when I dislike it so much? I can tell my coordinating teacher doesn't like it either because she never teaches it. I think she avoids it because she hates it like I do. Talk about math anxiety? You bet I've got that! I think my own kids do to. They hate math just like me!
>
> After
>
> One day I was teaching a concept and literally cried in front of my kids because I didn't get it either. When I expressed my disdain towards mathematics and my students witnessed my meltdown, they immediately shut down and I lost them during math lessons for weeks afterwards. I know that seeing their teacher get frustrated with the math left a long-lasting if not lifelong impression on them. Talk about "not doing that"! Well, I

> did it! I've had to make myself move forward because my students expected me to be confident and knowledgeable enough to help them be successful. It's so stressful! (p. 97)

Teachers are responsible for providing mathematics training; hence, the idea that their level of mathematics anxiety has been examined makes sense. Khalil et al. (2019) suggest that "it is now more imperative than ever to examine the emotional and cognitive abilities of teachers to teach mathematics in order to serve all students with a socially fair and equitable education" (p. 277). Elementary teachers demonstrate mathematics anxiety, seek ways that emphasize other subjects instead of mathematics, and even use methodologies that non-anxious teachers would not employ simply to help themselves get past mathematics anxiety (Adeyemi, 2015; Geist, 2015; Maloney & Beilock, 2012). Preservice teachers have also noted that past classroom experiences shaped attitudes toward mathematics (Bekdemir, 2010). Past classroom experiences included the manner by which both teachers and classmates responded to the experiences when they had difficulties understanding mathematics, the rate of the material covered, and even the influence of parents pushing success in mathematics (Bekdemir, 2010).

Mathematics Anxiety Causes

The causes of mathematics anxiety continue to be investigated to identify the techniques that could diminish or even solve the problem. Baloglu and Kocak (2006) contend that "there is still no clear answer as to the nature and causes of this anxiety;" nonetheless, many researchers have found what they believe to be multiple causes (p. 1331).

In their research examining 514 sets of twins, Wang et al. (2014) attributed the cause of mathematics anxiety to genetic and environmental factors. In this study, the participants were elementary students, each of whom was visited in their home and had a three-hour visit from a researcher. Mathematics anxiety, general anxiety, problem-solving skills, and reading comprehension skills were all measured during these visits. Wang et al. (2014) suggested that further efforts need to be undertaken to understand how each child develops mathematics anxiety and a general sense of anxiety. They added that researchers should work to increase math understanding while simultaneously reducing mathematics anxiety.

Gender differences repeatedly emerge in the literature, with much research focusing on children because the symptoms of mathematics anxiety appear early in life (Van Mier et al., 2019). However, some researchers, including Hart and Ganley (2019), have opted to analyze how mathematics anxiety influences adults. “Mild to moderate levels of math anxiety” were found among 1,000 participants in their study (Hart & Ganley, 2019, p. 134). Women had a higher incidence of mathematics anxiety as opposed to men, which also correlated to lower scores on mathematical proficiency in the same study. However, the results indicated that “participants who completed graduate or professional school had significantly lower (by about a half standard deviation) math anxiety than participants who had education equal to or less than graduating from a 2-year college” (Hart & Ganley, 2019, p. 132). Teachers need to be aware of the gender differences in mathematics anxiety and mathematical proficiency and recognize that mathematics anxiety can be mitigated with more education.

Another explanation points to negative experiences in mathematics (Rubinsten & Tannock, 2010). Negative mathematical experiences can start at home or school (Rubinsten & Tannock, 2010, p. 2). The mathematics anxiety of elementary teachers has an influence on the students, especially the girls in the classroom, regarding who is perceived to be the best at mathematics (Beilock et al., 2010). Teaching methods influence mathematics anxiety (Boyd et al., 2014). However, not all teachers are effective communicators of mathematics principles, thereby creating issues for student understanding (Boyd et al., 2014). Some teachers focus on whole-class instruction instead of working with individual students (Gresham, 2018; Isiksal et al., 2009; Whyte & Anthony, 2012). Teachers with mathematics anxiety do not use standards-based instruction methods but focus on the textbook rather than the student (Burton, 2012). Thus, they miss the opportunity to teach students to understand mathematics individually. Items indeed require memorization; nonetheless, teachers who merely focus on memorization, speed, or accuracy can lead a student to become mathematically anxious. Students need teachers who also offer clear explanations for developing concepts, include opportunities for critical thinking, and provide examples that relate mathematics to the world (Boaler, 2014; Geist, 2010). Teachers must also be careful to include all students during explanations. Mathematically anxious teachers will limit expectations for students (Mizala et al., 2015). Unfortunately, these teachers will also expect less from the female students than the male students (Beilock et al., 2010). They also have a tendency to recommend alternative methods of education to struggling students instead of adjusting the method of teaching to fit the needs of students (Mizala et al., 2015).

Mathematically anxious teachers struggle with how to be supportive academically and emotionally to students who struggle with mathematics (Flegg et al., 2013). Bursal and Paznokas (2006) found that teachers with a low level of math anxiety are more confident about teaching elementary mathematics when compared to their peers who have a high level of math anxiety (p. 175). University students that came from high schools with low mathematics requirements experience a relatively higher level of mathematics anxiety (Núñez-Peña et al., 2013). Students with a strong desire to succeed can have a higher level of mathematics anxiety than those with lower achievement emotions (Goetz et al., 2013; Kesici & Erdogan, 2010). In other words, when a student has a strong desire to be successful but fails in the mathematical task, greater anxiety can be experienced to achieve success. By contrast, students with a moderate to low desire to achieve may have less anxiety because they do not have to worry about how they perform (Kesici & Erdogan, 2010; Moustafa et al., 2017). The idea of performance is not simply related to the classroom. Individuals with mathematics anxiety can see the effects anywhere mathematical skills are used (Moustafa et al., 2017).

Mathematics Anxiety Interventions

Mathematics anxiety is not a new phenomenon, and various techniques for reducing such anxiety have been examined. Previous studies either reported how the population found ways to deal with mathematics anxiety or how the population responded to certain research interventions. Skaalvik (2018) examined the mathematics anxiety of 939 middle school students in Norway. Students who focused on the problems by seeking help, working harder, or analyzing errors in their work had lower levels of mathematics anxiety than those who attempted to avoid difficulties in mathematics (Skaalvik, 2018, pp. 721-722). Students who feel that they have control despite their mathematics anxiety seem to do better in mathematics (Lyons & Beilock, 2012).

Boyd et al. (2014) investigated the beliefs of 223 preservice early childhood and elementary education degree holders regarding their external and internal views on mathematics and mathematics anxiety. These preservice teachers typically attributed their perceptions of mathematics externally to the quality of the teacher. Sometimes a teacher made the learning enjoyable or acted in a demeaning manner toward a student who poorly performed (Boyd et al., 2014, p. 212). Preservice teachers also internally recognized that they addressed mathematics tasks differently because of a natural ability or lack thereof. They again linked the teacher to these feelings because of encouragement or discouragement (Boyd et al., 2014, p. 213). As preservice teachers discussed anxiety about teaching mathematics, they acknowledged the value of mathematics and expressed a need to encourage students, as their previous teachers had done to them. Preservice teachers believed that making learning enjoyable and personal would be the best way to teach mathematics (Boyd et al., 2014, p. 214). Learning mathematics from a teacher who knows the content, understands pedagogy, and cares for students to meet their needs creates the best classroom setting (Boyd et al., 2014, p. 215). Teachers need to express positive attitudes about learning mathematics; however, they themselves may struggle with the idea of teaching mathematics (Dowker et al., 2016).

Gresham (2018) conducted mixed-methods research to determine if the levels of mathematics anxiety had changed among elementary teachers once they started teaching as opposed to when they were preservice teachers. The participants had previously participated in a study as preservice teachers to provide a benchmark for them. After five years of teaching, the teachers had observed a slight decrease in mathematics anxiety as compared to when they were still in training (Gresham, 2018, p. 102). The teachers believed that the mathematics teaching methods course was valuable to them in reducing anxiety; thus, teacher colleges need to provide more mathematics content training to further diminish mathematics anxiety (Gresham, 2018, p. 102). An interesting conclusion was derived:

> It is only when teachers recognize that they have mathematics anxiety, know its cause, and are motivated to find help to reduce it, that they can help build confidence in mathematics and promote positive attitude toward mathematics. (Gresham, 2018, p. 104)

Given the emotional connections associated with mathematics anxiety, previous research used a variety of techniques connected to the emotional aspect of the classroom. Park et al. (2014) explored how expressive writing would influence the mathematics anxiety and achievement of 80 college students. A control group was asked to sit quietly while the intervention group was instructed to use expressive writing. Expressive writing is a technique that merely allows people to write about what they are feeling at the time. In this case, the students knew that they were going to take a mathematics test. The researchers analyzed students through a screening process to determine whether they had a low or high level of mathematics anxiety. Students were randomly assigned to the control and intervention groups. The researchers found that expressive writing reduced the mathematics anxiety and increased the mathematics performance of the students in the control group (Park et al., 2014, p. 108). Feelings and thoughts about mathematics do play a role in mathematics performance.

Salazar (2019) conducted a quasi-experimental study to determine if the mathematics anxiety of undergraduate business students could be reduced with mandala coloring activities. A mandala is “a sacred circle with various designs derived from Tibetan Buddhism” (Salazar, 2019, p. 135). These types of drawings have been utilized in other settings where art therapy has been used to reduce anxiety. The Math Anxiety Rating Scale-Revised was employed to measure the mathematics anxiety of the participants in a pretest and posttest design for both the treatment and control groups. The treatment group had two sub-levels in that some participants had a pre-drawn mandala to color, whereas another group did a free-color mandala. The control group was asked to simply doodle on paper instead of doing any coloring at all. The study included 106 participants. The results revealed that coloring pre-drawn or merely free coloring a mandala did reduce the mathematics anxiety of business statistics students as opposed to those who simply colored by doodling. Salazar (2019) also identified differences in the effects of the intervention in a comparison of male and female students. The male students who participated in the mandala coloring reduced their mathematics anxiety more than the female students. Art therapy is a technique that can serve as a mathematics anxiety intervention.

Classroom structure has an impact on mathematics anxiety; hence, various researchers have examined what happens to the mathematics anxiety of students if the classroom structure is changed. Segumpan and Tan (2018) conducted an experiment within the Philippine context to determine if a flipped classroom would help reduced the mathematics anxiety of secondary school students. They also aimed to ascertain if the mathematics performance would increase for these same participants. The goal was to verify if a more student-centered approach to learning instead of a teacher-directed approach would help mathematics anxiety and performance. Ninety students were involved in the quasi-experimental study. The experimental group was placed in a flipped learning setting, whereas the control group was placed in a teacher-directed setting. The flipped learning setting had instructional videos that students were expected to watch, followed by collaborative work in the classroom on the mathematics concepts. The teacher-directed setting had a presentation of concepts, questions, practice time, and homework that was completed before the next lecture. The mathematics anxiety was rated based on the Mathematics Self-Efficacy and Anxiety Questionnaire. Students also took a teacher-made geometry test to assess their mathematics performance. The results of the study indicated a statistically significant effect on reducing the mathematics anxiety of the participants in the flipped classroom. The results also showed an improvement in the mathematics performance of those participants in the flipped learning group. Segumpan and Tan (2018) suggest that teachers use various technologies to prepare students before and after they come to class to supplement any learning done in the classroom. Classroom structure does play a role in mathematics anxiety and achievement.

Dove and Dove (2017) compared different forms of flipped learning to understand mathematics anxiety. They found that the best form of mathematics education for preservice teachers involved a student-directed approach. However, this approach is not easily accepted by current mathematics teachers or by those training the next generation of teachers (Dove & Dove, 2017, pp. 303-304). Dove and Dove (2017) examined how preservice teachers would compare on mathematics anxiety levels if they received instruction from a classroom teacher, flipped classroom with teacher-made videos, or flipped instruction using Khan Academy videos. The researchers found that the anxiety scores were the lowest when flipped learning occurred with teacher-made videos. A significant finding was that the students perceived their mere participation in the mathematics content course as having reduced their mathematics anxiety. The researchers believed that the flipped versions of the class found ways to "incorporate more opportunities for interaction and communication within and between students and the instructor" (Dove & Dove, 2017, p. 328).

As mathematics anxiety is highly prevalent, even ideas that may seem simple have still been researched. Supekar et al. (2015) conducted an eight-week study of third graders. The intervention was simply intense tutoring that helped the participants to become more comfortable with mathematics topics. This outcome was even seen through functional MRI scans. The tutoring sessions "occurred three times per week and were each 40-50 minutes in duration" (Supekar et al., 2015, p. 12576). The researchers specifically examined the results in the amygdala, which is the part of the brain most connected to human emotions (Supekar et al., 2015). The research revealed that participants who started with abnormal readings in the amygdala showing a heightened sense of anxiety ended up with reduced anxiety after the eight-week tutoring sessions. Repeated exposure to mathematics was believed to have reduced the fear (Supekar et al., 2015, p. 12581). This result is significant for preservice teachers and those who train them to understand. Increasing exposure to mathematics helps mathematics anxious individuals to work through mathematics despite their anxiety.

The idea of being anxious about mathematics can be extremely frustrating for preservice teachers that they find ways to cope with the problem. Finlayson (2014) indicated that preservice teachers had found ways to relax, build self-confidence, increase practice time, seek the appropriate help, and rely on encouragement from family (p. 109). Clearly, teachers do not want to be anxious about what they are teaching. Finlayson (2014) also described traditional teaching methods of teachers lecturing and students merely memorizing answers as ineffective approaches to mathematics teaching. Teachers must find ways to engage students in the practice of teaching. Teachers who are math-anxious tend to use lecture-style methods of teaching mathematics. They focus on memorization and following algorithms rather than understanding how mathematics works. By contrast, teachers who are less math-anxious adopt a variety of methods to convey material to students, including visuals, individual and group work, and even games (Gresham, 2018). Sometimes coping with the problem involves finding others who have similar feelings and identifying ways to work together. As preservice elementary teachers recognize others with similar issues, whether they are related to academic or anxiety concerns, they learn how to support each other. Working together could transpire in small or large groups both inside and outside the classroom (Gonzalez-DeHass et al., 2017; Gresham, 2007). An important step is to speak plainly and openly about the topic of mathematics anxiety with preservice teachers. When math-anxious individuals discuss mathematics anxiety and mathematics struggles, they recognize that they are not alone and consequently find ways to support each other. Discussing anxieties with others is indeed a better approach (Hiebert & Grouws, 2007; Maloney & Beilock, 2012).

The idea of whether a method for reducing mathematics anxiety continues to be beneficial even after time has passed is important to acknowledge. Gresham (2018) examined inservice teachers who had previously participated in a study of mathematics anxiety while completing preservice elementary education courses. Gresham found that the additional teaching time had reduced mathematics anxiety. The inservice teachers reported that they needed more support as preservice teachers and suggested that mathematics content and pedagogy courses should include more opportunities to develop an understanding of mathematics. Furthermore, the inservice teachers found that when they involve students in mathematical thinking instead of simply presenting, they themselves and the students feel more confident. Some of the participants in the study completed a master's degree with the same teacher who had taught them undergraduate mathematics methods courses. These individuals observed the largest decrease in mathematics anxiety. They believed that such outcome was derived from the intense study of mathematics principles, more explanation of alternative teaching methods, and an open discussion of mathematics anxiety. Other researchers have obtained similar results for the value of a completed master's degree in helping to reduce the mathematics anxiety of inservice teachers (Bursal & Paznokas, 2006; Kim, 2014).

McCoy (2019) analyzed the technique of mindfulness to help preservice elementary teachers diminish their mathematics anxiety. Mindfulness refers to the "conscious act of being aware of the present, accepting past mistakes without labeling them or oneself as bad, learning from them, and moving on with life" (McCoy, 2019, p. 2). Participants were given journals to track their thoughts and provided instructions on how to use mindfulness, which even included breathing exercises. This mixed-methods research showed mixed results, with some participants having a slight decrease in anxiety, whereas others had a small increase in anxiety. Ramirez, Shaw, et al. (2018) similarly reported that "math-anxious students with appropriate appraisal cues and meaning-making frameworks may help them overcome their otherwise maladaptive appraisal of disfluent math experiences" (p. 153).

Samuel and Warner (2019) also investigated the influence of mindfulness on the mathematics anxiety of community college students. They added to the research knowledge by combining the intervention of mindfulness with a growth mindset included in the classroom curriculum. Mindfulness is a meditation technique that focuses a person on the moment through breathing techniques. Samuel and Warner (2019) focused on the participants' intervention before the latter's exposure to mathematics. The experimental group began mathematics lectures during the study with one-minute deep breathing exercises along with the repetition of phrases (i.e., "I am capable of understanding math") to develop a growth mindset. The participants were encouraged to keep repeating such phrases and to concentrate on their breathing if they experienced feelings of anxiety during the lecture. The Revised Math Anxiety Rating Scale (Alexander & Martray, 1989) was used for measuring mathematics anxiety both as a pretest and a posttest tool. The participants in the experimental group reported lower mathematics anxiety scores compared to the control group. This study was unique in that it lasted an entire school year. When the students reached halfway through the year, the control group was also given the intervention. Both groups showed a decrease in mathematics anxiety and an increase in mathematics performance by the end of the school year. The participants pointed to the repetitive nature of the exercises as being helpful for them to remember they were capable of being successful in mathematics. The results imply that teachers should focus not only on what content is delivered but also on how students are receiving that content.

New advances in technology provide not only different ways to deliver classroom content but also the possibility of reducing mathematics anxiety. Davis and Kahn (2018) used virtual reality to confirm if it could reduce the mathematics anxiety and increase the mathematics performance of undergraduate students enrolled in a developmental mathematics course. Fiftynine students participated in the study. The students were randomly assigned to control and treatment groups. Mathematics anxiety was measured by the Math Anxiety Rating Scale-Revised, whereas mathematics performance was measured via a researcher-created quiz. All the items were given as a pretest and a posttest. The intervention group watched five-minute relaxation programs that were videos of nature and nature sounds. The intervention group had a lower mathematics anxiety score compared to the control group. The intervention group also had higher scores on the researcher-created quiz. Technology offers new classroom opportunities to help students manage their emotions. Teachers also need to be aware of different methods such as this study used to assist students in decreasing their mathematics anxiety.

The influence of the training of preservice elementary teachers cannot be overstated. The way that these programs and professors provide examples of classroom practices and specific techniques for dealing with mathematics anxiety does have an impact on preservice teachers (Barrett, 2013; Bekdemir, 2010). Both the mathematics pedagogy training and mathematics content requirements teachers should understand have an influence on preservice elementary teachers. Preservice elementary teachers have shown a decrease in mathematics anxiety via the level of enthusiasm expressed by their teacher (Gresham, 2007). This enthusiasm could come from a teacher showing the application of the mathematics principles to real life or even keeping the discussion time positive when students are having trouble. The trainers of preservice teachers should consider how they react to classroom situations or even how they respond to emails (Karunakaran, 2020). Students need to know that the teacher is supportive of them (Sloan, 2010). Preservice elementary teachers should consider that students do not desire to have their performance discussed publicly. Teachers should be considerate of these feelings to avoid creating anxious moments in class. Privately handling this concern would be a better approach for the teacher to help preservice elementary teachers focus on their needs (Gonzalez-DeHass et al., 2017). Teachers who are accepting of their own mistakes and teach those mistakes provide preservice teachers with an opportunity to become comfortable with their own mistakes (Finlayson, 2014).

Mathematics Achievement

Mathematics anxiety is consistently examined in the literature along with mathematics achievement, with the purpose of assisting in the reduction of anxiety and the improvement of achievement. Researchers may investigate multiple reasons for mathematics achievement issues in students; nonetheless, the fact remains that anxiety plays a role (Beilock & Maloney, 2015; Dowker et al., 2016; Ramirez, Hooper, et al., 2018). Low achievement in mathematics causes issues that people and countries must address. The factor that worsens matters is that the mathematics anxiety of teachers creates anxiety and achievement issues for students (Ramirez, Hooper, et al., 2018). Some anxious teachers even expect mathematics students to have a lower level of achievement (Mizala et al., 2015). When students are allowed to progress from one year of school to the next, they should be able to assume that they have been given the requisite tools for success at the next grade level. These requisites include the ability to achieve in mathematics despite any fears or anxiety that the students may have. When students graduate from high school, they should also assume they have been given the tools required for success in college. Instead, students of math-anxious teachers develop an anxious view of mathematics (Mizala et al., 2015). The fact that elementary teachers with mathematics anxiety sometimes use incorrect teaching methods also does not help (Finlayson, 2014). Preservice teachers and those who train them need to understand this influence and seek ways to minimize this negative influence. Furthermore, math teachers “need to address head on the issue of math anxiety which often manifests itself as hesitancy or learned helplessness in observed math achievement" (Vasquez-Colina et al., 2014, p. 38).

Current Achievement Status

More students are being encouraged to attend college, but they typically find themselves unprepared for college mathematics courses. The Department of Education projects a 9% increase in college enrollment between fall 2009 and fall 2018 (U. S. Department of Education, 2010a). Colleges examine the prior mathematics achievement of applicants because students who are ready for college mathematics have a greater likelihood of attaining success in the workforce (Olson, 2006). A lack of mathematics achievement by high school students as they transition to college is a problem supported by evidence. One evidence is the increased number of students taking remedial or developmental courses at colleges across the United States. Between 1995 and 2000, approximately 22% of incoming college students required remediation in mathematics (Parsad & Lewis, 2003). In 2000, Parsad and Lewis (2003) surveyed post-secondary institutions to determine the percentage of these schools that offered remedial mathematics courses. Parsad and Lewis found that 71% of the institutions offered such courses. Interestingly, "institutions typically offered more remedial courses in mathematics than in reading or writing" (Parsad & Lewis, 2003, p. 9). In 2004, approximately 26% of incoming college students required remediation in mathematics at four-year institutions, whereas roughly 38% required remediation in mathematics at two-year institutions (Chen et al., 2010). This remedial work is expensive for American taxpayers. Remedial coursework is estimated to cost the nation about $2 billion annually (Fulton, 2010). According to Stigler et al. (2010), developmental mathematics creates difficulties for students who are attempting to obtain or complete a college degree.

Community colleges typically have the responsibility of dealing with students who are not college-ready. Unfortunately, "developmental mathematics students often meet all other admission standards but have limited educational options because of their poor mathematics skills" (Duranczyk & Higbee, 2006, p. 23). These colleges have courses in developmental studies, bridging courses, or remedial coursework. These courses would be any class that must be taken based upon poor placement exam results at college (Corbishley & Truxaw, 2010). Colleges use scores on college-produced placement tests, high school transcripts, and national tests (i.e., ACT or SAT) to determine placement in developmental courses. Squires (2008) indicated that an effective predictor for placement would be the overall student records, including high school mathematics performance.

Interestingly, the students who are placed into these programs have been studied. Hirumi et al. (2010) found that developmental mathematics courses were taken by 31% Caucasians, 46% African Americans, 51% Hispanics, and 29% Asians. Toro-Troconis and Mellström (2010) compared the self-efficacy of students enrolled in an intermediate algebra course to students enrolled in calculus. Intermediate algebra is normally a developmental course at most colleges. The researchers reported that the calculus students had a higher self-efficacy of math skills compared to the intermediate algebra students. Toro-Troconis and Mellström (2010) suggested that "teachers of developmental mathematics courses create a learning environment conducive to fostering self-efficacy in developmental students while keeping the rigor of the course comparable to other college courses" (p. 28). Program structure and sequencing could have an impact on this self-efficacy. According to Stigler et al. (2010), colleges have "developmental mathematics courses that start with basic arithmetic, then go on to pre-algebra, elementary algebra, and finally intermediate algebra, all of which must be passed before a student can enroll in a transfer-level college mathematics course" (p. 4). Bourgonjon et al. (2011) indicated that supplemental instruction at the community college helps to support even the weaker students in developmental math. In a study examining the math anxiety of students taking developmental math courses, Pivec (2007) suggested that teachers consider using a variety of techniques such as collaboration, slowing instruction, multiple test opportunities, and tutoring. Ashby et al. (2011) compared the instructional techniques of distance-based, face-to-face, and online learning for developmental math students and found that the face-to-face students performed better than the other two groups.

Taking college remedial courses shows evidence of a lack of high school mathematics achievement; however, other means of showing a lack of mathematics achievement are found. College teachers have noted concerns over the poor mathematics skill levels represented by recent high school graduates. A recent study revealed that college faculty rated the average incoming college students' mathematical abilities as *poor* or *very poor* (Corbishley & Truxaw, 2010). More than 47% of 2010 high school graduates in the United States took the ACT, but only 43% of these students were deemed college mathematics-ready by ACT. ACT has set benchmarks for testing, which have been shown to reflect success in college mathematics courses (ACT, 2010). The National Assessment of Educational Progress (NAEP) tracks mathematics proficiency in the United States. The most recent report from the NAEP shows a slight increase in the overall mathematics ability of high school students; however, the report also demonstrates that only 26% of the students tested are considered proficient in mathematics (U. S. Department of Education, 2010b). Another article has stated that nearly one-third of the students on their way to college are unprepared for college mathematics (Long et al., 2009). These cases are only a few examples found in the literature, which represent the mathematics achievement of college students, including elementary education majors, before they enter college.

Summary

Multiple perspectives on mathematics anxiety are examined in this chapter. Teachers at various stages seek methods for resolving the issue of mathematics anxiety in the hope of increasing mathematics achievement. One of the methods proposed by various groups involves teaching methods, which explains the continuing debate over the correct classroom pedagogy. Mathematics anxiety and mathematics achievement have an influence on the development of students at various stages of their educational career.

CHAPTER THREE: METHODS

Overview

The aim of this chapter is to provide readers with an understanding of the design of this study along with the research question and hypothesis. The purpose of this study is to determine the effects of motivational messages delivered via supplemental videos on preservice elementary education majors' mathematics anxiety. The setting and participants selected are discussed for the study. In addition, this chapter outlines the instrumentation, procedures, and data analyses for the study to show the methods for gathering and analyzing the data.

Design

A quasi-experimental posttest nonequivalent control group research design was used for the study. Gall et al. (2007) describe this type of design as the most common type of quasi-experimental design. Quasi-experimental designs allow for the control of an intervention but exclude the random assignment of participants (Gall et al., 2007). The participants in the current study were self-enrolled in undergraduate courses and therefore non-random. The use of intact groups is typical in educational settings, especially when the creation of as little disruption to participants as possible is necessary (Gall et al., 2007). Motivational messages as the independent variable pertain to messages of encouragement, empathy, and advice (Keller & Suzuki, 2004). They are generally positive messages that are intended to help individuals believe that, with sufficient effort, they can also complete a task. The independent variable comprises two levels: exposure to motivational messages in supplemental videos and non-exposure to motivational messages in supplemental videos. The dependent variable of mathematics anxiety is defined as feelings of panic, helplessness, and mental disorganization that occur when people face the manipulation of numbers and solving mathematics problems in various situations such as school settings and daily life (Richardson & Suinn, 1972).

Research Question

The following research question is addressed in this study:

RQ1: Does a significant difference exist in the mathematics anxiety of preservice elementary education majors who view supplemental videos embedded with motivational messages and preservice elementary education majors who view videos without embedded motivational messages?

Null Hypothesis

The null hypothesis for this study is as follows:

H_{01}: No significant difference exists in the mathematics anxiety of preservice elementary education majors who view supplemental videos embedded with motivational messages and preservice elementary education majors who view videos without embedded motivational messages.

Participants and Setting

Participants

The participants in this study were preservice elementary education majors who were taking one of two mathematics courses at a college in Florida during the spring semester of school year 2022–2023. The student participants were primarily in their freshman or sophomore year of college, working toward a B.S. in Elementary Education in a residential environment. Students who complete this training are qualified upon degree completion to teach Grades 1–6, with some receiving optional training for qualifications to teach nursery school through kindergarten. The participants were primarily female, Caucasian, and approximately 21 years old. The sample consisted of one male and 31 female participants. Elementary education majors were selected through convenience sampling. Elementary education majors self-enrolled in one of two different mathematics courses. One course had two sections of an elementary school arithmetic skills course for preservice teachers that was used for this study. Everyone who takes this course is an elementary education major enrolled at the same college in the Southern United States. The other course in which elementary education majors are enrolled is a liberal arts mathematics course that most majors at the same college in the Southern United States take. Elementary education majors were spread throughout seven sections of the course. Only the data from the elementary education majors were used in the analysis. Although the inclusion of at least 100 participants would have been the best approach for statistical power purposes, only 32 participants were ultimately included in the study. This type of sample is used in this study because of the nature of the intact groups and their convenient accessibility to the researcher (Warner, 2020).

The elementary education majors were encouraged to participate in the present study through extrinsic and intrinsic measures. Extrinsically, the participants were motivated by the opportunity to win one of nine $25 Amazon gift cards if they watched all the supplemental videos and completed the questionnaire. Nine gift cards were used such that a participant from each course section would have a chance to win a gift card. All the students enrolled in the courses were part of the drawing to win gift cards, whether they were elementary education majors or not. However, only data from the elementary education major participants were collected for analysis. The participants will be intrinsically motivated by the fact that the study can help the college understand how the students learn mathematics, potentially decrease mathematics anxiety, and promote the effective training of future preservice elementary education majors. To increase the internal validity of the study and to only analyze the data of those who watched the supplemental videos, the learning management software of the college was used to identify the specific participants who did and did not watch the videos.

Setting

This study was conducted at a college in the Southern United States. The college enrolls roughly 4,500 students in the undergraduate program. Approximately 60 different degrees are offered at the college. The college has students from all 50 states and 65 different countries. The education department has been training educators for 50 years. One course that elementary education majors take is an elementary school arithmetic skills class. This course is a review of the arithmetic topics taught in kindergarten and elementary grades. This course meets for 50 minutes on two days each week. The objective of this course is to ensure that students master the arithmetic skills needed to teach kindergarten and elementary topics. Another course that education majors take is a liberal arts mathematics course. This course is taken by most majors at the college. The course examines problem-solving skills and topics related to algebra, geometry, mathematical logic, and statistics. This course has two different meeting formats: meetings lasting 50 minutes for three days each week or meetings lasting 75 minutes for two days each week.

Instrumentation

Mathematics anxiety was measured using the Mathematics Anxiety Rating Scale-Revised (MARS-R; see Appendix C for the instrument). The original MARS test was created by Richardson and Suinn in 1972. The test, which takes about 45 minutes to complete, consists of 98 items for which participants must rate their level of anxiety about various mathematical situations on a Likert scale ranging from 1 (“not at all”) to 5 (“very much”). The scores on the test are summed, with a higher score signifying a higher degree of mathematics anxiety (Richardson & Suinn, 1972). The test–retest reliability for the test is 0.78 after two weeks (Suinn et al., 1972). To examine construct validity, Richardson and Suinn (1972) administered the Differential Aptitude Test and MARS to junior and senior undergraduate students. The Differential Aptitude Test is commonly given to evaluate mathematics skills. Richardson and Suinn (1972) found that the Pearson product–moment correlation coefficient between scores on the two tests was -.64 ($p < .01$). This result indicated that higher scores on the MARS produced lower scores on the mathematics test. Given the popularity of the MARS, various versions of the test have been created to assess mathematics anxiety in various age groups. The MARS and its various versions have been used in numerous studies (Asanjarani & Zarebahramabadi, 2021; Lake & Kelly, 2014; Malenfant, 2021).

The Mathematics Anxiety Rating Scale-Revised (MARS-R) is a shortened version of the original MARS and was used in this study (Alexander & Martray, 1989). The MARS-R has been employed in other studies to examine the mathematics anxiety of preservice elementary teachers (Wilson, 2013), paramedic students (Khasawneh et al., 2021a), and statistics course students (Samuel & Warner, 2019). An email request was sent on July 1, 2013 to Dr. Livingston Alexander, seeking his permission to use the test. He granted permission on July 5, 2013 and reaffirmed his permission on December 12, 2022. A copy of the correspondence is found in Appendix B. This MARS-R has been correlated .97 with the original MARS test (Plake & Parker, 1982). The test consists of 25 items for which participants must rate their level of anxiety about various mathematical situations on a Likert scale ranging from 1 (“not at all”) to 5 (“very much”). The test takes about 20 minutes to complete. MARS-R scores are the sums of these values, with scores ranging from 25 to 125. A lower score denotes a low degree of mathematics anxiety, whereas a higher score indicates a higher degree of mathematics anxiety. Alexander and Martray (1989) itemized the reliability of the test by the factors measured (see Table 1 for factor reliability). Researchers have used the MARS-R to examine the mathematics anxiety of various groups (Berkowitz et al., 2015; García-Santillán et al., 2018; Lake & Kelly, 2014).

Table 1

MARS-R Factor Reliability

Factor	Cronbach's Alpha
Math Test Anxiety	0.96
Numerical Test Anxiety	0.86
Math Course Anxiety	0.84

Procedures

Prior to conducting the study, materials were prepared and submitted to the Institutional Review Board (IRB) of Liberty University (LU; see Appendix D for the IRB approval notification). After obtaining the LU IRB approval, approval from the college was also received (refer to Appendix E for the approval from the college). After receiving the full approval from the IRBs of both institutions, the researcher began the research by coordinating with the classroom professors and department chairs for the best time for the research to commence in the classroom setting. Setting this time was necessary to coordinate the topics that were included in the supplemental videos. Videos were created, which coincided with approximately two weeks of topics in the mathematics courses. A two-week period occurred because of the time available in the courses. Once the topics were determined, the supplemental videos embedded with and without motivational messages were produced. The videos included the researcher explaining the step-by-step process for solving the mathematics problems. The videos were included in the learning management software component of the courses. During the two weeks of the study, the college courses met as normal without any changes to the content that was taught. The courses met at their regular class times and completed the normal curriculum designed for the course for two weeks. During the two weeks, the participants were to watch the supplemental videos outside of class time. Participants in the treatment group watched supplemental videos embedded with motivational messages that covered concepts in the enrolled course, whereas participants in the control group watched supplemental videos without embedded motivational messages that covered concepts in the enrolled course. Each mathematics course needed six supplemental videos embedded with motivational messages and six supplemental videos without embedded motivational messages. As two different mathematics courses are available, 12 control group videos and 12 treatment group videos were produced for the two-week study.

At an orientation meeting for the professors, the professors received an overview of the study and were asked to present course content as normal. The researcher provided the professors with a script of what to say in class about the study. The script briefly described the purpose of the study, the participant responsibilities, the incentives for participation, and instructions to complete the informed consent if the students intended to be participants in the study (see Appendix E for the teacher script for this study). The participants enrolled in the mathematics course as part of normal college course registration. The participants are assumed to best represent the population of preservice elementary education majors at the site of the study and the wider population of preservice elementary education majors.

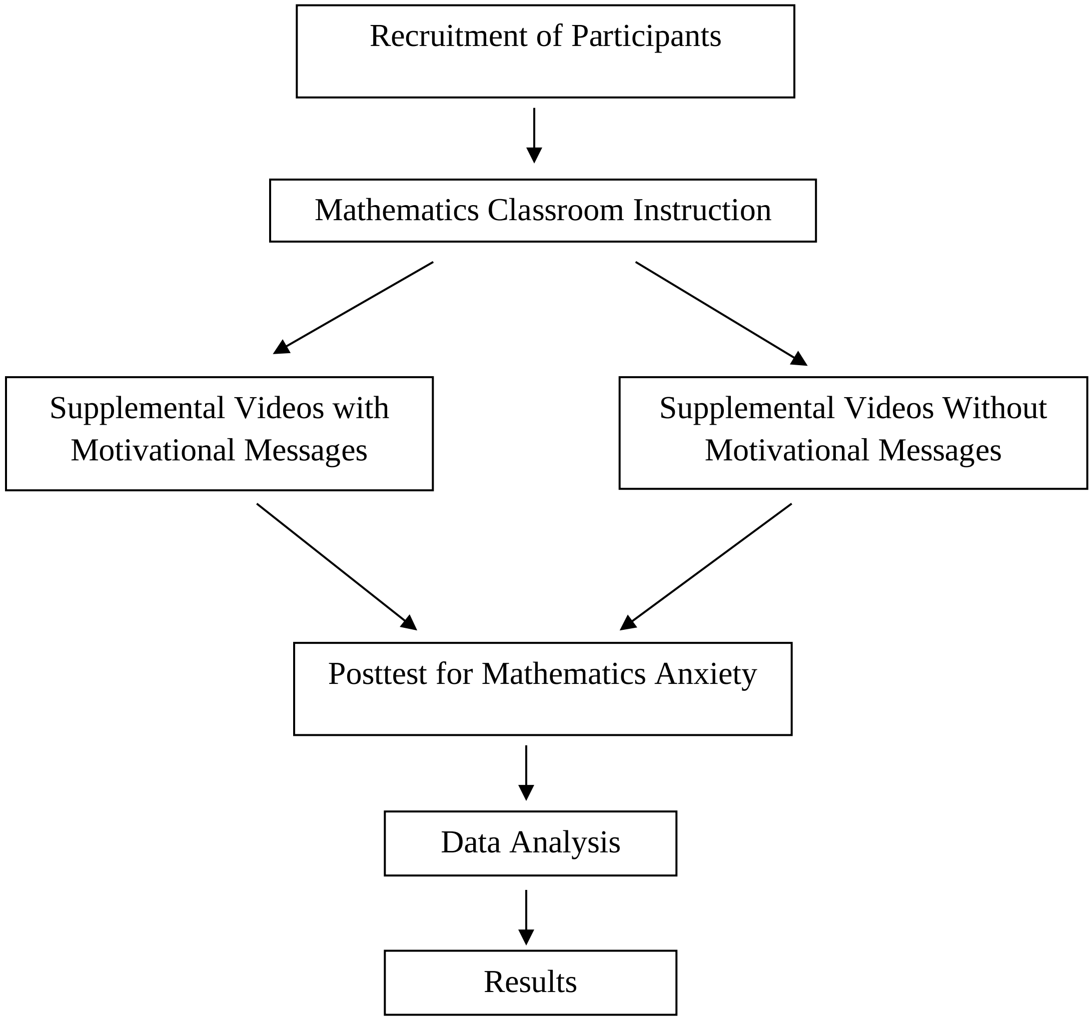
For a participant orientation meeting, the professors took a portion of the class time to read the prepared script and administer and collect an informed consent form for participation in the study. The class period for that day will follow the course curriculum.

The incentive was only given to those who participated in all the portions of the study and was distributed at the end of the study through email. Participants who were eligible were determined by examining learning management software data on their participation. The participants receiving the treatment were asked to watch the supplemental videos associated with each classroom lecture after they had received the same classroom instruction. Demographic information was needed for the study and was collected through surveys at the end of the study. Any of this information collected throughout the study was stored on a password-protected computer. The student participants were assigned numbers to anonymously identify them and correlate them on the testing instrument. To diminish the amount of disruption to class time and to control access to data, SurveyMonkey was used to administer the MARS-R. Students were provided a link to the learning management software and encouraged to complete the test by a set deadline if they watched all the videos and wished to join in the drawing for the $25 Amazon gift cards. Demographic information was collected during the MARS-R test. The financial incentive was distributed after the deadline to complete the test had passed. Once the experiment was complete, the analysis began. Posttest data were entered into Statistical Package for the Social Sciences (SPSS) on a password-protected computer.

After the two-week study, the participants were posttested, and the data analysis commenced. The research design schema is shown in Figure 1.

Figure 1

Research Design Flowchart



Note: The figure illustrates the plan for the research. The research began with the recruitment of participants. Two groups of participants were in mathematics courses for preservice elementary education. One group received supplemental videos embedded with motivational messages, whereas another group received supplemental videos without motivational messages. Upon the completion of the time frame for the research, a posttest of mathematics anxiety occurred for both groups, along with data analysis and reporting of the results.

Data Analysis

This study employed an independent samples *t*-test as the primary inferential statistical procedure. The independent samples *t*-test was appropriate for this analysis because there is only one dependent variable and an independent variable with two groups (Gall et al., 2007). The independent samples *t*-test was also appropriate for the current study because the independent variable is categorical and consists of two groups: with and without motivational messages. The dependent variable was measured on a continuous scale and determined any difference between the groups on the dependent variable. The dependent variable was mathematics anxiety as measured by the MARS-R instrument. The *t*-test can establish the differences in the mean scores using the MARS-R instrument and effectively identify any significant difference.

An independent *t*-test was conducted to evaluate whether a statistically significant difference exists between the mean mathematics anxiety scores as measured by the MARS-R of elementary education majors who view supplemental videos with and without motivational messages. Convenience sampling and independent observations were assumed. Before running the independent *t*-test, the data were inspected for extreme outliers and tested for the assumption of normality and the assumption of equal variance. The assumption of normality was checked using the Shapiro–Wilk test. The variances of the two populations were checked using Levene's test. The results of the independent *t*-test were determined. Graphs of the data along with descriptive statistics are reported in chapter four.

CHAPTER FOUR: FINDINGS

Overview

The purpose of this study was to see if motivational messages could reduce the mathematics anxiety of preservice elementary education majors. The independent variable comprised two levels: exposure to motivational messages in supplemental videos and non-exposure to motivational messages in supplemental videos. The dependent variable of mathematics anxiety was defined as feelings of panic, helplessness, and mental disorganization that occur when people face the manipulation of numbers and solving mathematics problems in various situations such as school settings and daily life (Richardson & Suinn, 1972). This chapter includes the research question, null hypothesis, descriptive statistics, data screening, assumption testing, and results.

Research Question

RQ1: Does a significant difference exist in the mathematics anxiety of preservice elementary education majors who view supplemental videos embedded with motivational messages and preservice elementary education majors who view videos without embedded motivational messages?

Null Hypothesis

$H_0$1: No significant difference exists in the mathematics anxiety of preservice elementary education majors who view supplemental videos embedded with motivational messages and preservice elementary education majors who view videos without embedded motivational messages.

Descriptive Statistics

The participants in this study were preservice elementary education majors who were taking one of two mathematics courses at a college in Florida during the spring semester of school year 2022–2023. The student participants were primarily in their freshman or sophomore year of college, working toward a B.S. in Elementary Education in a residential environment. The participants were primarily female, Caucasian, and approximately 21 years old. The participants were enrolled in one of two required mathematics courses. The demographic characteristics of the control and treatment groups are summarized in Table 2. The control group included both male and female participants, whereas the experimental group comprised only female participants. Hispanic students represented 6.7% in the control group and 5.9% in the treatment group. The proportions of 19- and 20-year-old students in the control group were 33.3% and 26.7%, respectively, compared to 40.6% and 15.6%, respectively, in the treatment group. The proportions of first- and second-year students in the control group were 40.0% and 53.3%, respectively, compared to 58.8% and 35.3%, respectively, in the treatment group. The proportion of students who achieved the highest cumulative GPA (3.00 to 4.00) was larger in the control group (67.7%) than in the treatment group (47.0%). Therefore, any differences between the mean scores for mathematics anxiety among the two groups of students may not be caused by the prescribed intervention but may be confounded by the effects of the differences in gender, race, age, academic class standing, program of study, and/or cumulative GPA. The descriptive statistics in Table 3 indicate very small differences between the mathematics anxiety scores of the two groups.

Table 2

Demographic Characteristics of the Control and Treatment Groups

Category	Control (*N* = 15)		Treatment (*N* = 17)		Total (*N* = 32)	
	n	% (within group)	*n*	% (within group)	*n*	% (within sample)
Gender						
Female	14	93.3	17	100.0	31	96.9
Male	1	6.7	0	0.0	1	3.1
Race						
White/Caucasian	14	93.3	16	94.1	30	93.8
Hispanic	1	6.7	1	5.9	2	6.2
Age (Years)						
18	2	13.3	6	25.0	8	25.0
19	5	33.3	8	40.6	13	40.6
20	4	26.7	1	15.6	5	15.6
21	2	13.3	0	6.2	2	6.2
22	2	13.3	2	12.5	3	12.5
Academic Class Standing						
1st year	6	40.0	10	58.8	16	50.0
2nd year	8	53.3	6	35.3	14	43.8
3rd year	1	6.7	1	5.9	2	6.2
Program of Study						
Elementary Education	15	100	17	100	32	100
Cumulative GPA						
< 2	1	6.7	2	11.8	3	9.4
2.00 to 2.49	0	0.0	1	5.9	1	3.1
2.50 to 2.99	4	26.7	6	35.3	10	31.2
3.00 to 3.49	4	26.7	3	17.6	7	21.9
3.50 to 4.00	6	40.0	5	29.4	11	34.4

Table 3

Descriptive Statistics for Mathematics Anxiety Scores

Independent variable	Without Motivational Messages		With Motivational Messages	
	M	*SD*	*M*	*SD*
Mathematics anxiety scores	66.73	22.15	65.24	18.21

Data screening was conducted. All the participants completed the MARS-R survey and answered every question on the survey. The total number of participants was 32.

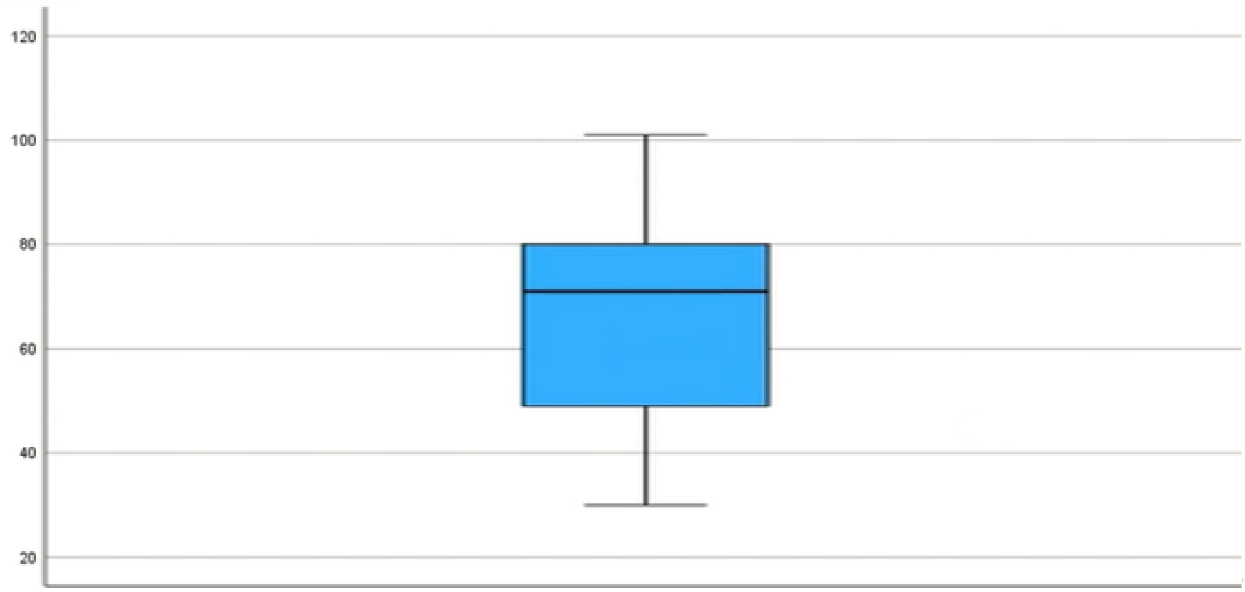
Results

Data Screening

Data screening was conducted on each group's dependent variables regarding data inconsistencies and extreme outliers (Warner, 2013). The data were sorted and scanned for inconsistencies using box and whisker plots. Extreme outliers are data points lying outside the adjacent values and are graphed using small circles (Warner, 2013). No extreme outliers were found in the data set.

Figure 2

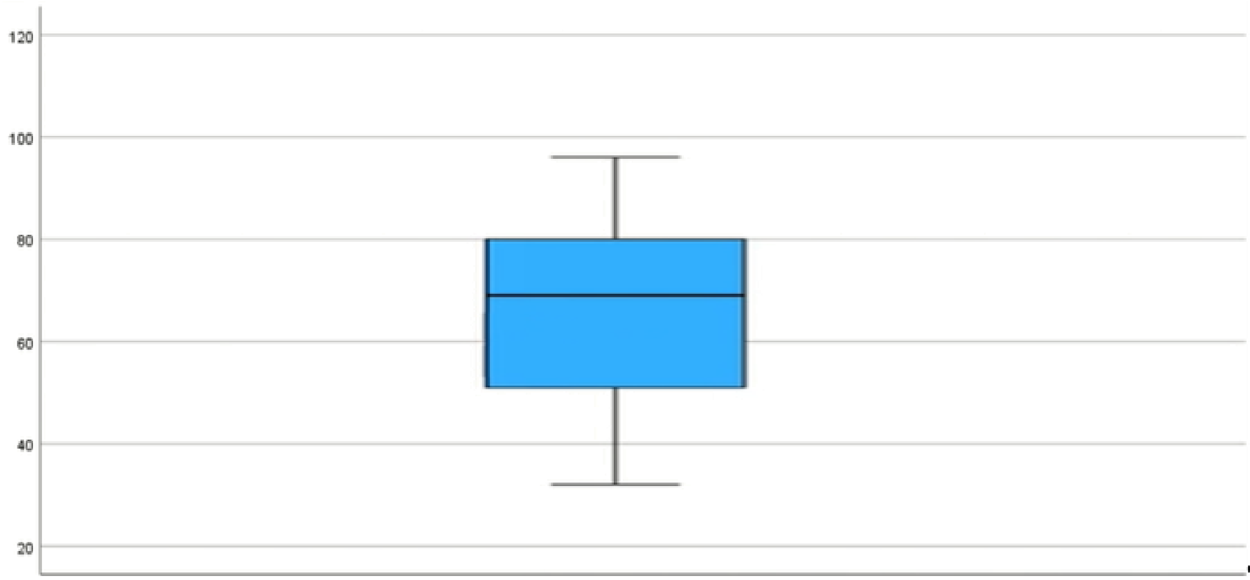
Box and Whisker Plot for Control Group



Note. The figure demonstrates the box and whisker plot for the control group. The control group received supplemental videos without motivational messages. The plot indicates no outliers for the control group.

Figure 3

Box and Whisker Plot for Treatment Group



Note. The figure demonstrates the box and whisker plot for the treatment group. The treatment group received supplemental videos with motivational messages. The plot indicates no outliers for the treatment group.

Assumptions

An independent samples *t*-test was utilized to test the null hypothesis that asks if a statistically significant difference exists in the mathematics anxiety of preservice elementary education majors who view supplemental videos embedded with motivational messages and preservice elementary education majors who view videos without embedded motivational messages. The *t*-test required six assumptions to be met (Gall et al., 2007). The first one was the assumption of a continuous dependent variable (Gall et al., 2007). This assumption was met because the present study had one dependent variable, mathematics anxiety scores, which was measured at the continuous level. The second assumption was the assumption that the data had been randomly sampled from a population (Gall et al., 2007). Quasi-experimental designs allow for the control of an intervention but exclude the random assignment of participants (Gall et al., 2007). The participants in the current study were self-enrolled in undergraduate courses and therefore non-random. The use of intact groups is typical in educational settings, especially when the creation of as little disruption to participants as possible is necessary (Gall et al., 2007). The assignment of participants to either the control or the experimental group was random. The third assumption was assumption that the data were normally distributed (Gall et al., 2007). The assumption of normality was met. The tests of normality are presented in Table 4. The Shapiro–Wilk test is used due to the small sample size ($n < 50$).

Table 4

Tests of Normality

Group	Shapiro–Wilk Test		
	Statistic	*df*	Sig.
Control	0.95	15	0.45
Treatment	0.98	17	0.95

Note: The table shows the tests of normality for the independent samples *t*-test for this study. The control and treatment groups had a significance value above 0.05; thus, the assumption of normality was met.

The fourth assumption was the assumption of the homogeneity of variance (Gall et al., 2007). The Levene's test of equality of error variance was conducted to evaluate the assumption of the homogeneity of variance for each variable (Gall et al., 2007). The assumption of homogeneity was met. Table 5 illustrates Levene's test.

Table 5

Levene's Test of Equality of Error Variance

F	*df*	Sig.
0.53	30	0.47

Note: The table shows the tests for equality of variances for the independent samples *t*-test for this study. The significance level was above 0.05; hence, the assumption of homogeneity was met.

Results of the Null Hypothesis

A *t*-test was conducted to test the null hypothesis that asks if a statistically significant difference exists in the mathematics anxiety of preservice elementary education majors who view supplemental videos embedded with motivational messages and preservice elementary education majors who view videos without embedded motivational messages. The statistical analysis conducted using SPSS revealed that a significant difference does not exist between the mathematics anxiety scores of preservice elementary education majors who view videos embedded with motivational messages and those preservice elementary education majors who view videos without embedded motivational messages. The null hypothesis failed to be rejected at the 95% confidence level $t(30) = 0.21$, $p = 0.84$. The effect size of 0.07 defined by Cohen's *d* is a very small one (Warner, 2013). The *t*-test results are shown in Table 6.

Table 6

t-test results

Independent variable	Without Motivational Messages		With Motivational Messages				Cohen's *d*
	M	*SD*	*M*	*SD*	*t*	*p*	
Mathematics anxiety scores	66.73	22.15	65.24	18.21	0.21	0.84	0.07

Note: The table shows the *t*-test results for the study. The *t*-statistic is 0.21 and the two-sided *p*-value is 0.84, indicating that the null hypothesis failed to be rejected at the 95% confidence level.

CHAPTER FIVE: CONCLUSIONS

Overview

In this chapter, the findings of the study are discussed in the context of the related literature and theory. The limitations of the study are also addressed. Finally, the implications of the study are discussed, and recommendations for future research are suggested.

Discussion

The purpose of this quasi-experimental posttest nonequivalent control group design was to test Pekrun's control-value theory and Keller's ARCS model of motivation theory as they relate to preservice elementary education majors' mathematics anxiety. This research sought to analyze the effects of an intervention on the mathematics anxiety of preservice elementary teachers. This population was examined because their views and understandings of mathematics have an effect on students (Schaeffer et al., 2021).

Research Question

The research question asked if any significant difference exists in the mathematics anxiety of preservice elementary education majors who view supplemental videos embedded with motivational messages and preservice elementary education majors who view videos without embedded motivational messages. Findings from the analysis failed to reject the null hypothesis that no significant difference exists in the mathematics anxiety of preservice elementary education majors who view supplemental videos embedded with motivational messages and preservice elementary education majors who view videos without embedded motivational messages.

Although this study failed to reject the null hypothesis, the fact remains that mathematics is an essential part of life, which helps all who understand it to not only gain knowledge for daily living but also cultivate the ability to think and reason rigorously. Many students avoid mathematics in daily life and even avoid taking higher mathematics courses when given the option because of their mathematics anxiety (Choe et al., 2019; Daker et al., 2021). People's prior experiences in mathematics will influence their motivations to learn mathematics in the future (Broda et al., 2023). Teachers are a factor in helping students understand and find the motivation to learn (Pekrun, 2021; Schaeffer et al., 2021). "If people who are anxious about math are charged with teaching others mathematics—as is often the case for elementary school teachers—teachers' anxieties could have consequences for students' math achievement" (Beilock et al., 2010, p. 1860). Preservice elementary teachers must understand and feel comfortable teaching foundational content knowledge that is needed in life (Browning et al., 2014; Jenßen et al., 2021). The level of mathematics achievement of K–12 students in the United States continues to be lower than in countries such as Singapore, Chinese Taipei, South Korea, Japan, Hong Kong, Russia, Ireland, Lithuania, Israel, Australia, and Hungary (Mullis et al., 2021). Research has indicated that mathematics achievement is influenced by mathematics anxiety, which is the value of this line of research (Zhang et al., 2019).

ARCS Model of Motivation

The Attention Relevance Confidence Satisfaction (ARCS) model was developed by John Keller as a means of using motivation in instructional settings (Keller, 1987). Motivational messages created through the ARCS model and used in research constitute messages of encouragement, empathy, and advice (Keller & Suzuki, 2004). A teacher might use phrases such as "You did a great job," "I know you can do this," "I noticed that you tried a new technique that works," "I understand this activity is frustrating right now, but keep trying," "We can do this together," or "This is a common mistake that can be overcome with practice." The ARCS model is essentially a synthesis of various theories of motivation. The objective of motivational theories is to explore the means of gaining a learner's attention, establish the relevance of the concepts to the learner, build confidence in the expectations and cultivate personal responsibility, and determine ways to help the instruction seem satisfying to the learner (Keller, 1987). According to expectancy-value theory, individuals will participate in an activity (i.e., learning in a classroom) if there is a reasonable expectation that the activity will provide them with some value (Wigfield & Eccles, 2000). These researchers have individually used their understanding of motivation to learn and their resulting theories to explore how students perceive and persist in the study of mathematics (Keller & Suzuki, 2004; Wigfield & Eccles, 2000).

The ARCS model of motivation was specifically used in the present study because it has been adopted in past research regarding mathematics anxiety. The purpose of its usage was the delivery of motivational messages. Hodges and Kim (2013) analyzed how the delivery of motivational messages through one supplemental video delivered before a test could influence the mathematics anxiety and mathematics achievement of college students. Although the effect size was small, the mathematics anxiety of the participants who received the intervention was deemed to have diminished. This study did not match these results, but the delivery of the supplemental videos was different from Hodges and Kim (2013). The current study provided multiple videos over the course of multiple lectures. Furthermore, in this study, research was performed at the end of a course instead of the beginning of the course. Multiple videos were assumed to have provided the capacity to reject the null hypothesis in this study, but such assumption did not materialize. A key aspect of the research completed by Hodges and Kim (2013) was its pretest and posttest design, which might have helped the present study to identify any significant difference in the level of mathematics anxiety. As no pre-test was part of the procedure and analysis in this study, the preexisting mathematics anxiety of the participants was improbable to determine.

Karakis et al. (2016) also applied the ARCS model of motivation to the mathematics anxiety of students. Moreover, they examined the mathematics achievement of their participants. A computer-assisted instructional design model was used to develop computer games embedded with motivational messages to hopefully encourage students to persist through the games of solving mathematical problems. The participants had the opportunity to play the games under the supervision of their classroom teacher and the researchers over the course of six weeks. Karakis et al. (2016) found through their pretest and posttest design that the participants' mathematical attitudes and achievement improved as a result of the experiment. The delivery method of the motivational messages was different through computer-assisted instruction as opposed to this study, which employed supplemental videos embedded with motivational messages crafted using the ARCS model. Nonetheless, the expectation for this study would be to obtain similar results because embedded motivational messages were used. The animated computer games would have possibly provided a more consistent implementation of the ARCS model as opposed to the method employed in this study. Extending this study in the future through a pretest and posttest design and employing a system to ensure more consistency in the application of the ARCS model, along with measuring mathematics achievement, should be a key consideration.

Control-Value Theory

The other theory utilized in this study was control-value theory as developed by Pekrun (2000). This theory was particularly relevant to the current study because of the emotion of anxiety that some people express when approaching mathematics. This theory was used in this study not for the methodology for the delivery of an intervention but rather for an explanation for how people think about their achievements and the resulting emotions. Control-value theory predicts that achievement emotions "influence cognitive resources, motivation, use of strategies, and self-regulation vs. external regulation of learning" (Pekrun et al., 2007, p. 16). If people anticipate that they have control over their own success in a task through effort on their part and such effort will lead to a positive outcome, then they will become more willing to try that task. Students who do not believe that they have control over their assigned task may make the judgment that trying such task is worthless. Students who also anticipate the shame of not completing the task may make a judgment call that trying such task is futile. Control-value theory helps to explain why anxiety could be occurring in students. According to Pekrun (2021), the motivation of a teacher is a key component of the learning process. The motivation provided by a teacher should convey "goals, wishes, and intentions related to performing actions and attaining desired states" (Pekrun, 2021, p. 313).

Control-value theory was specifically used in the present study because it has been used in past research regarding mathematics anxiety. The research that was connected to control-value theory was not always connected to motivational messages such as the ones used in Keller's ARCS model. Goetz et al. (2013) applied control-value theory to investigate the mathematics anxiety of female students. Testing a treatment to reduce mathematics anxiety was not the goal of the research. In this manner, the research for this study involving a control and a treatment group with an intervention of motivational messages was significantly different from the research of Goetz et al. (2013). Aside from showing that mathematics anxiety does exist in female students, the research by Goetz et al. (2013) used a much larger sample (N = 584) and demonstrated a more balanced representation between male and female students than the current study, which only had one out of 32 participants. No features or elements in control-value theory would suggest that males would react differently than females. However, research by others does suggest that a difference exists; thus, achieving a more balanced representation would be a beneficial approach for future studies (Mizala et al., 2015; Schaeffer et al., 2021).

Control-value theory was also used in a study of preservice elementary teachers by Jenßen et al. (2022). Again, this research was not designed to test an intervention related to mathematics; instead, the goal was to continue to identify how the emotions connected to mathematics can be better understood by validating survey instruments. This type of research of preservice elementary teachers is necessary but is different from the focus of the current study; hence, the results of that study only serve to inform this research on the body of literature and the value of this and other studies. Furthermore, the present study could be extended by examining the mathematics achievement of participants as compared to their mathematics anxiety through a validated instrument for mathematics achievement.

Implications

Mathematics anxiety continues to affect preservice (Lavidas et al., 2023; Sie & Agyei, 2023) and inservice teachers (Gresham, 2018). The results of the current study indicated that no difference existed between the group of participants who received supplemental videos with embedded motivational messages and the group of participants who received supplemental videos without embedded motivational messages; nevertheless, no conclusion should be drawn that motivational messages as represented by the attempt of this research to apply Keller’s ARCS model and Pekrun’s motivational theories should be dismissed from future research. Pekrun’s theories continue to be used for research regarding preservice teachers (Jenßen et al., 2022; Wu et al., 2021). Multiple limiting factors were identified, with a small sample size being the most notable, which could have influenced the results of this study. The research on motivation to learn should be continued because other studies continue to help people understand and diminish their mathematics anxiety (Živković et al., 2023). As mathematics anxiety continues to be recognized as an issue for preservice elementary teachers, researchers must continuously find ways to minimize the mathematics anxiety of preservice elementary teachers (Schanke, 2022).

Research is abundant regarding the existence of mathematics anxiety in preservice elementary education majors and how it influences not only their acquisition of mathematics and pedagogical practices but also their own students. This line of research should be continued because preservice elementary education majors have some of the highest levels of mathematics anxiety when compared to others with different majors (Gonzalez-DeHass et al., 2017; Van der Sandt & O'Brien, 2017). The current research contributed to the overall literature by continuing to document the existence of mathematics anxiety in this population. This research should encourage others to further explore the impact of motivational messages to reduce the mathematics anxiety of preservice elementary education majors. In addition, this research should help drive conversations and promote action plans by schools of education to assist in the reduction of the mathematics anxiety of preservice teachers. Education professors should introduce preservice elementary teachers to the body of literature surrounding the mathematics anxiety of preservice elementary teachers, with special attention to various intervention methods and the influence a teacher may have on the mathematics anxiety of their own students (Khasawneh et al., 2021b). The cycle of teachers passing on their own anxieties must be broken.

All the professors and participants involved in this study were aware of the provided information regarding mathematics anxiety. This experiment and the mere discussion of mathematics anxiety with the professors and participants in this study may have long-term implications for them in future college mathematics classes and their own classroom teaching. In fact, “It is only when teachers recognize that they have mathematics anxiety, know its cause, and are motivated to find help to reduce it, that they can help build confidence in mathematics and promote positive attitude toward mathematics” (Gresham, 2018, p. 104). Preservice teachers in the present study who are aware of their own hesitancies with mathematics might prompt them to pursue strategies that would be more beneficial to them (Jenßen et al., 2021).

Limitations

A key limitation is the generalizability of this research. This research was undertaken at a college in the Southern United States at a set time. Convenience sampling was used because of the researcher’s connection to the potential participants. The premise that the results could be applied to other preservice elementary education majors at other colleges or even at the same college should not be assumed (Gall et al., 2007). This convenience sample also influenced the number of participants available to the researcher, which constituted a clear limitation of this study. A minimum sample of 100 participants would have been better to meet research standards (Gall et al., 2007).

Another limitation of the current study is connected to the instrument. Participants self-reported their answers to the MARS-R test regarding their own mathematics anxiety. The participants needed to understand that their answers would be confidential and would have no negative influence on their enrolled course success. Moreover, the participants should not feel embarrassed to answer the instrument questions.

The study was similarly limited by the exact mathematical content taught during the supplemental videos. One explanation might be the fact that the researcher was not the participants’ professor, thereby creating the issue of some of the content probably being taught differently from the professor's perspective. Nevertheless, every effort was made to minimize this issue through communication between the researcher and the professors.

A final limitation of this study was the teacher's impact on the delivery of the motivational messages and testing instruments. Although a script of suggested motivational messages was used when creating the treatment videos, the suggested messages might not have been clearly connected to the ARCS model or could have been better applied in the dialogue of the supplemental videos (Warner, 2020).

Recommendations for Future Research

This research and its findings indicate a variety of ways to continue the examination of the mathematics anxiety of preservice elementary education majors. The following recommendations are suggested for future research:

1. Additional research is needed with the same population but with a larger sample size. The current study identified preservice elementary education majors with a high level of mathematics anxiety. However, the treatment of motivational messages could not indicate a statistical difference between the control and treatment groups. A larger sample size would possibly show different results. The population could also be spread over multiple university campuses, given that the created videos contained mathematics content specific to the enrolled mathematics courses.
2. Future research should also consider a longer time frame for the delivery of the motivational messages. Delivering the messages over the course of five videos was probably insufficient to exert an influence on the participants' perceived mathematics anxiety (Gresham, 2018).

3. This study only had one male participant, and the participants were primarily Caucasian. Future research should be more diverse. This suggestion has to be placed into context due to the voluntary nature of any research.
4. Additional research should explore the participants' mathematics anxiety in pretest and posttest settings. The current study did not examine the mathematics anxiety of the participants before the treatment of motivational messages began. An understanding of the participants' preexisting mathematics anxiety could potentially reveal any further influence of the treatment (Davis & Kahn, 2018).
5. The literature about the connection between mathematics anxiety and the achievement of preservice elementary education majors is abundant; hence, future research should also connect the treatment of motivational messages with an analysis of the participants' mathematics achievement. This idea could be further developed as a pretest and posttest design. A validated mathematics achievement instrument would need to be used.
6. This research was undertaken at the end of a mathematics course. Future research could be conducted near the beginning of the mathematics course. The participants would have less influence from their professor on their preexisting mathematics anxiety and mathematics achievement. A researcher applying this intervention early in the course might create an environment earlier in the course for lower mathematics anxiety and greater mathematics achievement. This assumes the intervention reduces mathematics anxiety in that study. Another reason to conduct the research earlier in a course is to ensure the inclusion of more participants. This study was undertaken at the end of a course term; thus, some potential participants might have possibly

already “checked out” for the summer, which explained their refusal to participate despite the offer of an incentive (Boulton et al., 2019).

REFERENCES

ACT. (2010). *Solutions for success in an evolving global market: ACT annual report September 1, 2009-August 31, 2010*. http://www.act.org/aboutact/pdf/AnnualReport10.pdf

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college*. U.S. Department of Education. http://www2.ed.gov/rschstat/research/pubs/toolboxrevisit/toolbox.pdf

Adeyemi, A. (2015). *Investigating and overcoming mathematics anxiety in in-service elementary school teachers* [Doctoral dissertation, University of Windsor]. https://scholar.uwindsor.ca/etd

Aizikovitsh-Udi, E., & Cheng, D. (2015). Developing critical thinking skills from dispositions to abilities: Mathematics education from early childhood to high school. *Creative Education*, *6*, 455-462. http://dx.doi.org/10.4236/ce.2015.64045

Akin, A., & Kurbanoglu, I. N. (2011). The relationships between math anxiety, math attitudes, and self-efficacy: A structural equation model. *Studia Psychologica*, *53*(3), 263-273. http://search.proquest.com

Alexander, L., & Martray, C. (1989). The development of an abbreviated version of the mathematics anxiety rating scale. *Measurement and Evaluation in Counseling and Development*, *22*(3), 143-150.

Asanjarani, F., & Zarebahramabadi, M. (2021). Evaluating the effectiveness of cognitive-behavioral therapy on math self-concept and math anxiety of elementary school students. *Preventing School Failure: Alternative Education for Children and Youth*, *65*(3), 223-229. https://doi.org/10.1080/1045988X.2021.1888685

Ashby, J., Sadera, W., & McNary, S. (2011). Comparing student success between developmental math courses offered online, blended, and face-to-face. *Journal of Interactive Online Learning*, *10*(3), 128-140. http://www.ncolr.org/jiol/issues/pdf/10.3.2.pdf

Ashcraft, M., & Krause, J. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review*, *14*(2), 243-248. https://doi.org/10.3758/BF03194059

Ashcraft, M., & Moore, A. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment*, *27*(3), 197-205. https://doi.org/10.1177/0734282908330580

Ashcraft, M., & Ridley, K. (2005). Math anxiety and its cognitive consequences. In J. D. Campbell (Ed.), *Handbook of Mathematical Cognition* (pp. 315-327). Psychology Press.

Aslan, D. (2013). Comparison of pre- and in-service preschool teachers' mathematical anxiety and beliefs about mathematics for preschoolers. *Academic Research International*, *4*(2), 225-230. http://www.savap.org.pk/journals/ARInt./Vol.4(2)/2013(4.2-22).pdf

Baloglu, M., & Kocak, R. (2006). A multivariate investigation fo the differences in mathematics anxiety. *Personality and Individual Differences*, *40*(7), 1325-1335. https://doi.org/10.1016/j.paid.2005.10.009

Baloğlu, M., & Zelhart, P. F. (2007). Psychometric properties of the revised mathematics anxiety rating scale. *Psychological Record*, *57*(4), 593-611. https://doi.org/10.1007/BF03395597

Barbaresi, W. J., Katusic, S. K., Colligan, R. C., Weaver, A. L., & Jacobsen, S. J. (2005). Math learning disorder: Incidence in a population-based birth cohort, 1976-82, Rochester, Minn. *Ambulatory Pediatrics*, *5*(5), 281-289. https://www.proquest.com/scholarly-journals/math-learning-disorder-incidence-population-based/docview/208562056/se-2

Barrett, D. (2013). Preservice elementary teachers' attitudes improve and math anxiety decreases with focus upon manipulatives use. *National Teacher Education Journal*, *6*(2), 5-10.

Battista, M. (1999). The mathematical miseducation of America's youth: Ignoring research and scientific study in education. *The Phi Delta Kappan*, *80*(6), 424-433. http://www.jstor.org/stable/20439469

Beilock, S., Gunderson, E., Gerardo, L., & Levine, S. (2010). Female teachers' math anxiety affects girls' math achievement. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(5), 1860-1863. https://doi.org/10.1073/pnas.0910967107

Beilock, S., & Willingham, D. (2014). Math anxiety: Can teachers help students to reduce it? *American Educator*, *38*(2), 28-32,43. http://www.aft.org/pdfs/americaneducator/summer2014/Beilock.pdf

Beilock, S. L., & Maloney, E. A. (2015). Math anxiety: A factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain Sciences*, *2*(1), 4-12. https://doi.org/10.1177/2372732215601438

Bekdemir, M. (2010). The pre-service teachers' mathematics anxiety related to depth of negative experiences in mathematics classroom while they were students. *Educational Studies in Mathematics*, *75*(3), 311-328. https://doi.org/10.1007/s10649-010-9260-7

Berkowitz, T., Schaeffer, M. W., Maloney, E. A., Peterson, L., Gregor, C., Levine, S. C., & Beilock, S. L. (2015). Math at home adds up to achievement in school. *Science*, *350*(6257), 196-198. https://doi.org/doi:10.1126/science.aac7427

Bethune, B. (2013). Five rules of what to look for in a school--and why the building doesn't matter, but the teachers do. *Maclean's*, *126*(34). http://www.macleans.ca/general/five-rules-of-what-to-look-for-in-a-school-and-why-the-building-doesnt-matter-but-the-teachers-do/

Boaler, J. (2014). Research suggests that timed tests cause math anxiety. *Teaching Children Mathematics*, *20*(8), 469-474. https://www.jstor.org/stable/10.5951/teacchilmath.20.8.0469

Boulton, C. A., Hughes, E., Kent, C., Smith, J. R., & Williams, H. T. P. (2019). Student engagement and wellbeing over time at a higher education institution. *PloS One*, *14*(11). https://doi.org/https://doi.org/10.1371/journal.pone.0225770

Bourgonjon, J., Valcke, M., Soetaert, R., de Wever, B., & Schellens, T. (2011). Parental acceptance of digital game-based learning. *Computers & Education*, *57*(1), 1434-1444. https://doi.org/10.1016/j.compedu.2010.12.012

Boyd, W., Foster, A., Smith, J., & Boyd, W. E. (2014). Feeling good about teaching mathematics: Addressing anxiety amongst pre-service teachers. *Creative Education*, *5*(4), 207-217. https://doi.org/10.4236/ce.2014.54030

Broda, M. D., Ross, E., Sorhagen, N., & Ekholm, E. (2023). Exploring control-value motivational profiles of mathematics anxiety, self-concept, and interest in adolescents. *Frontiers in Psychology*, *14*(1140924). https://doi.org/10.3389/fpsyg.2023.1140924

Browning, C., Edson, A., Kimani, P., & Aslan-Tutak, F. (2014). Mathematical content knowledge for teaching elementary mathematics: A focus on geometry and measurement. *The Mathematics Enthusiast*, *11*(2), 333-383. https://scholarworks.umt.edu/tme/vol11/iss2/7

Brunye, T., Mahoney, C., Giles, G., Rapp, D., Taylor, H., & Kanarek, R. (2013). Learning to relax: Evaluating four brief interventions for overcoming the negative emotions accompanying math anxiety. *Learning and Individual Differences*, *27*(October), 1-7. https://doi.org/10.1016/j.lindif.2013.06.008

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science & Mathematics*, *106*(4), 173-180.

Burte, H., Gardony, A. L., Hutton, A., & Taylor, H. A. (2020). Elementary teachers' attitudes and beliefs about spatial thinking and mathematics. *Cognitive research: principles and implications*, *5*(1), 17-17. https://doi.org/10.1186/s41235-020-00221-w

Burton, M. (2012). What is math? Exploring the perception of elementary pre-service teachers. *Issues in the Undergraduate Mathematics Preparation of School Teachers: The Journal*(5). https://files.eric.ed.gov/fulltext/EJ970350.pdf

Chang, H., & Beilock, S. L. (2016). The math anxiety-math performance link and its relation to individual and environmental factors: a reveiw of current behavioral and psycholphysiological research. *Current Opinion in Behavioral Sciences*, *10*(10), 33-38. https://doi.org/10.1016/j.cobeha.2016.04.011

Chang, M., & Lehman, J. (2013). Learning foreign language through an interactive multimedia program: An experimental study on the effects of the relevance component of the ARCS model. *the CALICO Journal*, *20*, 81-98.

Chen, X., Wu, J., & Tasoff, S. (2010). *Academic preparation for college in the high school senior class of 2003−04* Washington, D.C.: U.S. Department of Education, National Center for Education Statistics http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2010169

Chinn, S. (2009). Mathematics anxiety in secondary students in England. *Dyslexia*, *15*(1), 61-68. https://doi.org/10.1002/dys.381

Choe, K. W., Jenifer, J. B., Rozek, C. S., Berman, M. G., & Beilock, S. L. (2019). Calculated avoidance: Math anxiety predicts math avoidance in effort-based decision-making. *Science Advances*, *5*(11). https://doi.org/10.1126/sciadv.aay1062

Corbishley, J. B., & Truxaw, M. P. (2010). Mathematical readiness of entering college freshman: An exploration of perceptions of mathematics faculty. *School Science and Mathematics*, *110*(2), 71-85. https://doi.org/10.1111/j.1949-8594.2009.00011.x

Daker, R., Gattas, S., Sokolowski, H., Green, A., & Lyons, I. (2021). First-year students' math anxiety predicts STEM avoidance and underperformance throughout university, independently of math ability. *NPJ Sci Learn*, *6*(1), 17. https://doi.org/10.1038/s41539-021-00095-7

Davis, T., & Kahn, S. (2018). Management of mathematics anxiety: Virtual relaxation interventions. *International Journal of Education and Social Science*, *5*(7), 38-44.

Devine, A., Fawcett, K., Szűcs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and brain functions : BBF*, *8*(1), 33-33. https://doi.org/10.1186/1744-9081-8-33

Devlin, K. (2000). *The language of mathematics: Making the invisible visible*. Henry Holt and Company. http://books.google.com/books?id=MVEOEYgU0-UC

Disabilities, N. C. f. L. (2006). Dyscalculia. http://www.ldonline.org/article/Dyscalculia/

Dove, A., & Dove, E. (2017). Flipping preservice elementary teachers' mathematics anxieties. *Contemporary Issues in Technology and Teacher Education*, *17*(3).

https://www.citejournal.org/volume-17/issue-3-17/mathematics/flipping-preservice-elementary-teachers-mathematics-anxieties

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology*, *7*(508). https://doi.org/10.3389/fpsyg.2016.00508

Dreger, R., & Aiken, L. (1957). The identification of number anxiety in a college population. *Journal of Educational Psychology*, *48*(6), 344-351. https://doi.org/10.1037/h0045894

Duranczyk, I., & Higbee, J. (2006). Developmental mathematics in 4-year institutions: Denying access. *Journal of Developmental Education*, *30*(1), 22-31.

Finlayson, M. (2014). Addressing math anxiety in the classroom. *Improving Schools*, *17*(1), 99-115. https://doi.org/10.1177/1365480214521457

Flegg, N., Mohamed, K., & Trimmer, K. (2013). Synthesizing the literature concerning math anxiety to inform a project on pre-service teacher retention rates. ASQ Advancing the STEM Agenda, Grand Rapids, MI.

Frenzel, A., Pekrun, R., & Goetz, T. (2007). Girls and mathematics —A "hopeless" issue? A control-value approach to gender differences in emotions towards mathematics. *European Journal of Psychology of Education*, *22*(4), 497-514. https://doi.org/10.1007/bf03173468

Frye, D. (2020). *What is dyscalculia? Math learning disability overview*. https://www.additudemag.com/what-is-dyscalculia-overview-and-symptom-breakdown

Fulton, M. (2010). *State reporting on remedial education: Analysis of findings*. Education Commission of the States. http://www.ecs.org/clearinghouse/85/27/8527.pdf

Gagnon, J., & Maccini, P. (2007). Teacher-reported use of empirically validated and standards-based instructional approaches to secondary mathematics. *Remedial and Special Education*, *28*(1), 43-56. https://doi.org/10.1177/07419325070280010501

Gall, M., Gall, J., & Borg, W. (2007). *Educational research: An introduction* (8th ed.). Pearson.

García-Santillán, A., Martínez-Rodríguez, V., & Escalera-Chávez, M. E. (2018). Perception toward task, test and courses of math in high school students: there are differences by gender? *International Journal of Developmental and Educational Psychology. Revista INFAD de Psicología.*, *1*(2), 171-190. https://doi.org/10.17060/ijodaep.2018.n2.v1.1337

Geist, E. A. (2010). The anti-anxiety curriculum: Combating math anxiety in the classroom. *Journal of Instructional Psychology*, *37*(1), 24-31.

Geist, E. A. (2015). Math anxiety and the "math gap": How attitudes toward mathematics disadvantages students as early as preschool. *Education*, *135*(3), 328-336. https://eis.hu.edu.jo/deanshipfiles/pub110226807.pdf#page=64

Goetz, T., Bieg, M., Lüdtke, O., Pekrun, R., & Hall, N. C. (2013). Do girls really experience more anxiety in mathematics? *Psychological Science*, *24*(10), 2079-2087. https://doi.org/https://doi.org/10.1177/0956797613486989

Gonzalez-DeHass, A. R., Furner, J. M., Vasquez-Colina, M. D., & Morris, J. D. (2017). Preservice elementary teachers' achievement goals and their relationship to math anxiety. *Learning and Individual Differences*, *60*, 40-45. https://doi.org/10.1016/j.lindif.2017.10.002

Gough, M. (1954). Why failures in mathematics? Mathemaphobia: Causes and treatments. *The Clearing House*, *28*(5), 290-294. http://www.jstor.org/stable/30176259

Gresham, G. (2007). A study of mathematics anxiety in preservice teachers. *Early Childhood Education Journal*, *35*(2), 181-188. https://doi.org/10.1007/10643-007-0174-7

Gresham, G. (2018). Preservice to inservice: Does mathematics anxiety change with teaching experience? *Journal of Teacher Education*, *69*(1), 90-107, Article https://doi.org/10.1177/0022487117702580.

Gresham, G. (2021). Exploring exceptional education preservice teachers' mathematics anxiety. *International Journal for the Scholarship of Teaching and Learning*, *15*(2), Article 13.

Grouws, D. A., & Cramer, K. (1989). Teaching practices and student affect in problem-solving lessons of select junior high mathematics teachers. In D. B. McLoed & V. M. Adams (Eds.), *Affect and mathematical problem solving: A new perspective* (pp. 149-161). Springer-Verlag.

Hadley, K., & Dorward, J. (2011). The relationship among elementary teachers' mathematics anxiety, mathematics instructional practices, and student mathematics achievement. *Journal of Curriculum and Instruction*, *5*(2), 27-44. https://doi.org/10.3776/joci.2011.v5n2p27-44

Han, J., & Yin, H. (2016). Teacher motivation: Definition, research development and implications for teachers. *Cogent Education*, *3*(1), 1217819. https://doi.org/10.1080/2331186x.2016.1217819

Hart, S. A., & Ganley, C. M. (2019). The nature of math anxiety in adults: Prevalence and correlates. *Journal of Numerical Cognition*, *5*(2), 122-139. https://doi.org/10.5964/jnc.v5i2.195

Haynes, S. (2003). *The effect of background music on the mathematics test anxiety of college algebra students* (Publication Number UMI No. 3132948) [Doctoral dissertation, ProQuest Dissertations & Theses.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33-46. http://www.jstor.org/stable/749455

Hiebert, J., & Grouws, D. A. (2007). The effects of classroom mathematics teaching on students' learning. *Second handbook of research on mathematics teaching and learning*, *1*, 371-404.

Hirumi, A., Appelman, B., Rieber, L., & Van Eck, R. (2010). Preparing instructional designers for game-based learning: Part 1. *TechTrends*, *54*(3), 27-37. https://doi.org/10.1007/s11528-010-0400-9

Hodges, C. B., & Kim, C. (2013). Improving college students' attitudes toward mathematics. *TechTrends*, *57*(4), 59-66. https://doi.org/http://dx.doi.org/10.1007/s11528-013-0679-4

Huett, J. B., Kalinowski, K. E., Moller, L., & Huett, K. C. (2008). Improving the motivation and retention of online students through the use of ARCS-based e-mails. *American Journal of Distance Education*, *22*(3), 159-176. https://doi.org/10.1080/08923640802224451

Isiksal, M., Curran, J. M., Koc, Y., & Askun, C. S. (2009). Mathematics anxiety and mathematics self-concept: Considerations in preparing elementary school teachers. *Social Behavior and Personality*, *37*(5), 631-644. https://doi.org/10.2224/sbp.2009.37.5.631

Jenßen, L., Eid, M., Szczesny, M., Eilerts, K., & Blömeke, S. (2021). Development of early childhood teachers’ knowledge and emotions in mathematics during transition from teacher training to practice. *Journal of Educational Psychology*, *113*(8), 1628-1644. https://doi.org/10.1037/edu0000518

Jenßen, L., Roesken-Winter, B., & Blömeke, S. (2022). Measuring pre-service primary teachers' shame in mathematics—a comprehensive validation study. *International Journal of Science and Mathematics Education*. https://doi.org/10.1007/s10763-022-10253-x

Jha, S. (2012). Parents and teachers role in reducing mathematics anxiety. *International Journal of Computer Applications in Engineering Sciences*, *2*(3), 259-262. http://www.caesjournals.org/uploads/IJCAES-CSE-2012-86.pdf

Karakis, H., Karamete, A., & Okcu, A. (2016). The effects of a computer-assisted teaching material, designed according to the ASSURE instructional design and the ARCS model of motivation, on students' achievement levels in a mathematics lesson and their resulting attitudes. *European Journal of Contemporary Education*, *15*(1), 105-113.

Karunakaran, M. (2020). Opportunities to decrease elementary prospective teachers' mathematics anxiety. *The Mathematics Enthusiast*, *17*(2&3), 469-492. https://scholarworks.umt.edu/tme/vol17/iss2/6/

Keller, J. (1987). Development and use of the ARCS model of instructional design. *Journal of Instructional Development*, *10*(3), 2-10. http://www.jstor.org/stable/30221294

Keller, J. (2010). *Motivational Design for Learning and Performance: The ARCS Model Approach*. Springer-Verlag. https://doi.org/10.1007/978-1-4419-1250-3

Keller, J., & Suzuki, K. (2004). Learner motivation and e-learning design: a multinationally validated process. *Journal of Educational Media, 29*(3), 229-239. https://doi.org/10.1080/1358165042000283084

Kesici, S., & Erdogan, A. (2010). Mathematics anxiety according to middle school students' achievement motivation and social comparison. *Education*, *131*(1), 54-63. https://link-galecom.ezproxy.liberty.edu/apps/doc/A239813824/BIC?u=vic_liberty&sid=BIC&xid=c86a33b3

Khalil, D., Lake, E., & Johnson, A. (2019). Teachers' classroom engagement structures: a comparative study of a novice US and an experience teacher. In M. S. Hannula, G. C. Leder, F. Leder, M. Morselli, M. Vollstedt, & Q. Zhang (Eds.), *Affect and mathematics education. Fresh perspectives on motivation, engagement, and identity. ICME-13 Monographs* (pp. 255-282). Springer, Nature.

Khasawneh, E., Gosling, C., & Williams, B. (2021a). The effect of self-efficacy on maths anxiety among paramedic students. *Australasian Journal of Paramedicine*, *18.* https://doi.org/https://doi.org/10.33151/ajp.18.814

Khasawneh, E., Gosling, C., & Williams, B. (2021b). What impact does maths anxiety have on university students? *BMC Psychology*, *9*(1), 37. https://doi.org/10.1186/s40359-021-00537-2

Kiemer, K., Gröschner, A., Pehmer, A.-K., & Seidel, T. (2015). Effects of a classroom discourse intervention on teachers' practice and students' motivation to learn mathematics and science. *Learning and Instruction*, *35*, 94-103. https://doi.org/https://doi.org/10.1016/j.learninstruc.2014.10.003

Kim, R. (2014). South Korean elementary teachers’ anxiety for teaching mathematics *International Journal of Elementary Education*, *3*(3), 71-80. https://doi.org/10.11648/j.ijeedu.20140303.14

Klein, D. (2007). A quarter century of US ‘math wars’ and political partisanship. *BSHM Bulletin: Journal of the British Society for the History of Mathematics*, *22*(1), 22-33. https://doi.org/10.1080/17498430601148762

Krinzinger, H., Kaufmann, L., & Willmes, K. (2009). Math anxiety and math ability in early primary school years. *Journal of Psychoeducational Assessment*, *27*(3), 206-225. https://doi.org/10.1177/0734282908330583

Lake, V. E., & Kelly, L. (2014). Female preservice teachers and mathematics: Anxiety, beliefs, and stereotypes. *Journal of Early Childhood Teacher Education*, *35*(3), 262-275. https://doi.org/10.1080/10901027.2014.936071

Lavidas, K., Skopeliti, I., Zacharos, K., & Panagiotounakos, E.-P. (2023). Preservice preschool teachers' mathematics experience and math anxiety on their beliefs about and attitudes toward teaching mathematics. *Journal of Early Childhood Teacher Education*, 1-18. https://doi.org/10.1080/10901027.2023.2196943

Legg, A. M., & Locker, L., Jr. (2009). Math performance and its relationship to math anxiety and metacognition. *North American Journal of Psychology*, *11*(3), 471.

Long, M., Iatarola, P., & Conger, D. (2009). Explaining gaps in readiness for college-level math: The role of high school courses. *Education Finance Policy*, *4*(1), 1-33. https://doi.org/10.1162/edfp.2009.4.1.1

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

Lyons, I. M., & Beilock, S. L. (2012). Mathematics anxiety: Separating the math from the anxiety. *Cerebral Cortex*, *22*(9), 2102-2110. https://doi.org/10.1093/cercor/bhr289

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education*, *30*(5), 520-540. http://www.jstor.org/stable/749772

Ma, X., & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: a longitudinal panel analysis. *Journal of Adolescence*, *27*(2), 165-179. https://doi.org/http://dx.doi.org/10.1016/j.adolescence.2003.11.003

Malenfant, W. (2021). *A quantitative study of mathematics anxiety in first-generation pre-service teachers* (Publication Number 3386) [Doctoral Dissertation, University of Maine]. Electronic Theses and Dissertations. https://digitalcommons.library.umaine.edu/etd/3386

Maloney, E., & Beilock, S. (2012). Math anxiety: who has it, why develops, and how to guard against it. *Trends in Cognitive Sciences*, *16*(6), 404-406. https://doi.org/10.1016/j.tics.2012.06.008

Mazzocco, M., & Myers, G. (2003). Complexities in identifying and defining mathematics learning disability in the primary school-age years. *Annals of Dyslexia*, *53*(1), 218-253. https://doi.org/10.1007/s11881-003-0011-7

McConnell, C., Hoover, G., & Sasse, C. (2001). Using the ARCS model to design motivating curriculum. *Allied Academies International Conference. Academy of Educational Leadership. Proceedings*, *6*(1), 119-123. http://ezproxy.liberty.edu/login?url=https://search.proquest.com/docview/192406971?accountid=12085

McCoy, W. (2019). Using mindfulness to reduce math anxiety in preservice elementary school teachers. *Peer Review*, *21*(1). https://www.aacu.org/peerreview/2019/winter-spring/McCoy

Mizala, A., Martínez, F., & Martínez, S. (2015). Pre-service elementary school teachers' expectations about student performance: How their beliefs are affected by their mathematics anxiety and student's gender. *Teaching and Teacher Education*, *50*, 70-78. https://doi.org/http://dx.doi.org/10.1016/j.tate.2015.04.006

Moustafa, A. A., Tindle, R., Ansari, Z., Doyle, M. J., Hewedi, D. H., & Eissa, A. (2017). Mathematics, anxiety, and the brain [Report]. *Reviews in the Neurosciences*, *28*(4), 417+. http://ezproxy.pcci.edu:2148/apps/doc/A518337869/AONE?u=pens82558&sid=AONE&xid=4b9ae0d5

Mullis, I. V. S., Martin, M. O., Fishbein, B., Foy, P., & Moncaleano, S. (2021). *Findings from the TIMSS 2019 problem solving and inquiry tasks*. https://timssandpirls.bc.edu/timss2019/psi/

National Center for Education Statistics. (2020). *Students with disabilities*. https://nces.ed.gov/programs/coe/indicator_cgg.asp

National Education Association. (1894). *Report of the committee of ten on secondary school studies with the reports of the conferences arranged by the committee*. American Book Company.

Neale, D. (1969). The role of attitudes in learning mathematics. *The Arithmetic Teacher*, *16*(8), 631-640. http://www.jstor.org/stable/41187564

Núñez-Peña, M. I., Suárez-Pellicioni, M., & Bono, R. (2013). Effects of math anxiety on student success in higher education. *International Journal of Educational Research*, *58*, 36-43. https://doi.org/http://dx.doi.org/10.1016/j.ijer.2012.12.004

Olson, L. (2006). Skills for work, college readiness are found comparable. *Education Week*, *25*(36), 1-19. http://www.edweek.org/

Owens, D. T. (Ed.). (1993). *Research ideas for the classroom: Middle grades mathematics*. Macmillan Publishing Co.

Park, D., Ramirez, G., & Beilock, S. L. (2014). The role of expressive writing in math anxiety. *Journal of Experimental Psychology: Applied*, *20*(2), 103-111. https://doi.org/https://doi.org/10.1037/xap0000013

Parsad, B., & Lewis, L. (2003). *Remedial education at degree-granting postsecondary institutions in fall 2000*. Washington, D.C.: U.S. Department of Education, National Center for Education Statistics http://nces.ed.gov/pubs2004/2004010.pdf

Passolunghi, M. C., Caviola, S., De Agostini, R., Perin, C., & Mammarella, I. C. (2016). Mathematics anxiety, working memory, and mathematics performance in secondary-school children [Original Research]. *Frontiers in Psychology*, *7*(42). https://doi.org/10.3389/fpsyg.2016.00042

Peker, M. (2009). Pre-service teachers' teaching anxiety about mathematics and their learning styles. *Eurasia Journal of Mathematics, Science, & Technology Education*, *5*(4), 335-345. http://www.ejmste.com/v5n4/eurasia_v5n4_peker.pdf

Pekrun, R. (2000). A social cognitive, control-value theory of achievement emotions. In J. Heckhausen (Ed.), *Motivational psychology of human development* (pp. 143-163). Elsevier.

Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, *18*(4), 315-341.

Pekrun, R. (2021). Teachers need more than knowledge: Why motivation, emotion, and self-regulation are indispensable. *Educational Psychologist*, *56*(4), 312-322. https://doi.org/10.1080/00461520.2021.1991356

Pekrun, R., Elliot, A. J., & Maier, M. A. (2006). Achievement goals and discrete achievement emotions: A theoretical model and prospective test. *Journal of Educational Psychology*, *98*(3), 583-597. https://doi.org/10.1037/0022-0663.98.3.583

Pekrun, R., Frenzel, A., Goetz, T., & Perry, R. (2007). The control-value theory of achievement emotions: An integrative approach to emotions in education. In P. Schutz & R. Pekrun (Eds.), *Emotion in Education* (pp. 13-36). Academic Press.

Pekrun, R., & Linnenbrink-Garcia, L. (2014). *International Handbook of Emotions in Education*. Taylor & Francis. https://books.google.com/books?id=zvUjAwAAQBAJ

Pivec, M. (2007). Editorial: Play and learn: Potentials of game-based learning. *British Journal of Educational Technology*, *38*(3), 387-393. https://doi.org/10.1111/j.1467-8535.2007.00722.x

Plake, B. S., & Parker, C. S. (1982). The development and validation of a revised version of the Mathematics Anxiety Rating Scale. *Educational and Psychological Measurement*, *42*, 551-557. https://doi.org/10.1177/001316448204200218

Platas, L. (2008). *Measuring teachers' knowledge of early mathematical development and their beliefs about mathematics teaching and learning in the preschool classroom* (Publication Number UMI No. 3367632) [Dissertation, ProQuest Dissertations & Theses.

Pletzer, B., Kronbichler, M., Nuerk, H. C., & Kerschbaum, H. H. (2015). Mathematics anxiety reduces default mode network deactivation in response to numerical tasks. *Frontiers in Human Neuroscience*, *9*(202). https://doi.org/10.3389/fnhum.2015.00202

Ramirez, G., & Beilock, S. (2011). Writing about testing worries boosts exam performance in the classroom. *Science*, *331*, 211-213. https://doi.org/10.1126/science.1199427

Ramirez, G., Gunderson, E., Levine, S., & Beilock, S. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development*, *14*(2), 187-202.

Ramirez, G., Hooper, S., Kersting, N., Ferguson, R., & Yeager, D. (2018). Teacher math anxiety relates to adolescent students' math achievement. *AERA Open*, *4*(1), 2332858418756052. https://doi.org/10.1177/2332858418756052

Ramirez, G., Shaw, S., & Maloney, E. (2018). Math anxiety: Past research, promising interventions, and a new interpretation framework. *Educational Psychologist*, *53*(3), 145-164. https://doi.org/10.1080/00461520.2018.1447384

Richardson, F., & Suinn, R. (1972). The mathematics anxiety rating scale: Psychometric data. *Journal of Counseling Psychology*, *19*(6), 551-554. https://doi.org/10.1037/h0033456

Rubinsten, O., & Tannock, R. (2010). Mathematics anxiety in children with developmental dyscalculia. *Behavioral and Brain Functions*, *6*(46). https://behavioralandbrainfunctions.biomedcentral.com/articles/10.1186/1744-9081-6-46

Salazar, L. R. (2019). Exploring the effect of coloring mandalas on students' math anxiety in business statistics course. *Business, Management and Education, 17*, 134-151. https://doi.org/10.3846/bme.2019.11024

Samuel, T., & Warner, J. (2019). "I can math!": Reducing math anxiety and increasing math self-efficacy using a mindfulness and growth mindset-based intervention in first-year students. *Community College Journal of Research and Practice, 45*, 1-18. https://doi.org/10.1080/10668926.2019.1666063

Schaeffer, M. W., Rozek, C. S., Maloney, E. A., Berkowitz, T., Levine, S. C., & Beilock, S. L. (2021). Elementary school teachers' math anxiety and students' math learning: A large-scale replication. *Developmental Science*, *24*(4), e13080. https://doi.org/10.1111/desc.13080

Schanke, A. (2022). Improving mathematical self-efficacy of preservice elementary teachers. *PRIMUS*, 1-14. https://doi.org/10.1080/10511970.2022.2068092

Schoenfeld, A. H. (2002). Making mathematics work for all children: Issues of standards, testing, and equity. *Educational Researcher, 31*(1), 13-25. https://doi.org/10.3102/0013189X031001013

Schubring, G. (2006). Researching into the history of teaching and learning mathematics: The state of art. *Paedagogica Historica*, *42*(4), 665-667. https://doi.org/10.1080/00309230600806955

Schunk, D., Pintrich, P., & Meece, J. (2008). *Motivation in education: Theory, research, and application* (3rd ed.). Pearson Merrill Prentice Hall.

Schwartz, S. (2020). Who's afraid of math? Turns out, lots of students. *Education Week*, *39*(31), 3-5. https://www.edweek.org/ew/articles/2020/05/06/whos-afraid-of-math-turns-out-lots.html

Segumpan, L. L. B., & Tan, D. (2018). Mathematics performance and anxiety of junior high school students in a flipped classroom. *European Journal of Education Studies*, *4*(12). https://doi.org/10.5281/zenodo.1325918

Sie, C. K., & Agyei, D. D. (2023). Relationship between pre-service teachers' mathematical knowledge for teaching fractions and their teaching practices: What is the role of teacher anxiety? *Contemporary Mathematics and Science Education*, *4*(2). https://doi.org/10.30935/conmaths/13252

Skaalvik, E. M. (2018). Mathematics anxiety and coping strategies among middle school students: relations with students' achievement goal orientations and level of performance [journal article]. *Social Psychology of Education*, *21*(3), 709-723. https://doi.org/10.1007/s11218-018-9433-2

Sloan, T. R. (2010). A quantitative and qualitative study of math anxiety among preservice teachers. *The Educational Forum*, *74*(3), 242-256. https://doi.org/10.1080/00131725.2010.483909

Soares, N., Evans, T., & Patel, D. R. (2018). Specific learning disability in mathematics: A comprehensive review. *Translational Pediatrics*, *7*(1), 48-62. https://doi.org/10.21037/tp.2017.08.03

Squires, D. (2008). *Curriculum alignment: Research-based strategies for increasing student achievement*. Corwin Press.

Stigler, J. W., Givvin, K. B., & Thompson, B. J. (2010). What community college developmental mathematics students understand about mathematics. *MathAMATYC Educator*, *1*(3), 4-16. http://www.amatyc.org/?page=MathAMATYCEducator

Suinn, R., Edie, C., Nicoletti, J., & Spinelli, P. (1972). The MARS, a measure of mathematics anxiety: Psychometric data. *Journal of Clinical Psychology*, *28*(3), 373-375. https://doi.org/10.1002/1097-4679(197207)28:3+%3C373::AID-JCLP2270280320%3E3.0.CO;2-C

Supekar, K., Iuculano, T., Chen, L., & Menon, V. (2015). Remediation of childhood math anxiety and associated neural circuits though cognitive tutoring. *Journal of Neuroscience*, *35*(35), 12574-12583. https://doi.org/10.1523/jneurosci.0786-15.2015

Tobias, S. (1994). *Overcoming math anxiety: Revised and expanded*. W. W. Norton & Company, Inc.

Toro-Troconis, M., & Mellström, U. (2010). Game-based learning in Second Life®. Do gender and age make a difference? *Journal of Gaming & Virtual Worlds*, *2*(1), 53-76. https://doi.org/10.1386/jgvw.2.1.53_1

U. S. Department of Education, National Center for Education Statistics. (2010a). *Digest of education statistics*. http://nces.ed.gov/pubs2010/2010013.pdf

U. S. Department of Education, National Center for Education Statistics. (2010b). *The nation's report card: Grade 12 reading and mathematics 2009 national and pilot state results*. http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2011455

U.S. Department of Education. (2008). *Foundation for success: The final report of the national mathematics advisory panel*. http://www2.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf

Utley, J., Moseley, C., & Bryant, R. (2005). Relationship between science and mathematics teaching efficacy of pre-service elementary teachers. *School Science & Mathematics*, *105*(2), 82-88. https://doi.org/10.1111/j.1949-8594.2005.tb18040.x

Van der Sandt, S., & O'Brien, S. (2017). Impact of instructor teaching style and content course on mathematics anxiety of preservice teachers. *Journal of Technology Education*, *29*(1).

Van Mier, H. I., Schleepen, T. M. J., & Van den Berg, F. C. G. (2019). Gender differences regarding the impact of math anxiety on arithmetic performance in second and fourth graders. *Frontiers in Psychology*, *9:2690*. https://doi.org/10.3389/fpsyg.2018.02690

Vasquez-Colina, M., Gonzalez-DeHass, A., & Furner, J. (2014). Achievement goals, motivation to learn, and mathematics anxiety among pre-service teachers. *Journal of Research in Education*, *24*(1), 38-52. https://files.eric.ed.gov/fulltext/EJ1098234.pdf

Visser, J. A. N., & Keller, J. M. (1990). The clinical use of motivational messages: an inquiry into the validity of the ARCS model of motivational design. *Instructional Science*, *19*(6), 467-500. http://www.jstor.org/stable/23369880

Vukovic, R., Kieffer, M., Bailey, S., & Harari, R. (2013). Mathematics anxiety in young children: Concurrent and longitudinal associations with mathematical performance. *Contemporary Educational Psychology*, *38*(1), 1-10. https://doi.org/10.1016/j.cedpsych.2012.09.001

Walmsely, A. (2003). *A history of the "new mathematics" movement and its relationship with current mathematical reform*. University Press of America.

Wang, Z., Hart, S. A., Kovas, Y., Lukowski, S., Soden, B., Thompson, L. A., Plomin, R., McLoughlin, G., Bartlett, C. W., Lyons, I. M., & Petrill, S. A. (2014). Who is afraid of math? Two sources of genetic variance for mathematical anxiety. *Journal of Child Psychology and Psychiatry*, 1-9. https://doi.org/10.1111/jcpp.12224

Warner, R. (2013). *Applied statistics: From bivariate through multivariate techniques* (2nd ed.). Sage Publications, Inc.

Warner, R. (2020). *Applied statistics II: Multivariable and multivariate techniques*. Sage Publications.

Wen, T. (2020, May 12). *The myth of being 'bad' at maths.* https://www.bbc.com/worklife/article/20200506-how-to-tackle-your-anxiety-about-maths

Whyte, J., & Anthony, G. (2012). Maths anxiety: The fear factor in the mathematics classroom. *New Zealand Journal of Teachers' Work*, *9*(1), 6-15.

Widjajanti, D. B., Listyani, E., & Retnowati, E. (2020). The profile of student math-anxiety. *Journal of Physics: Conference Series*, *1581*. https://doi.org/10.1088/1742-6596/1581/1/012059

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68-81. https://doi.org/10.1006/ceps.1999.1015

Wilson, S. (2013). Investigating pre-service teachers' mathematics anxiety using the Revised Mathematics Anxiety Scale (RMARS). *Australian and International Journal of Rural Education*, *23*(3), 1-11.

Wolkowicz, J. (2011). Dyscalculia: A condition that doesn't add up. *The Times*. http://www.nwitimes.com/news/state-and-regional/illinois/article_3589f7ec-82e2-55b4-a214-3777d02dabdb.html

Wu, C., Gong, X., Luo, L., Zhao, Q., Hu, S., Mou, Y., & Jing, B. (2021). Applying control-value theory and unified theory of acceptance and use of technology to explore pre-service teachers' academic emotions and learning satisfaction [Original Research]. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.738959

Wu, S., Barth, M., Amin, H., Malcarne, V., & Menon, V. (2012). Math anxiety in second and third graders and its relation to mathematics achievment. *Frontiers in Psychology*, *3*. https://doi.org/10.3389/fpsyg.2012.00162

Yao, J. J. (2008). Study on mathematics learning disability children's solving complex arithmetical problems. *International Journal of Psychology*, *43*(3-4), 525-525.

Zelkowski, J. (2010). Secondary mathematics: Four credits, block schedules, continuous enrollment? What maximizes college readiness? *Mathematics Educator*, *20*(1), 8-21. http://math.coe.uga.edu/tme/Issues/v20n1/20.1_Zelkowski_p.8-21.pdf

Zhang, J. (2022). A longitudinal study of Pekrun's control-value theory and the internal/external frame of reference model in predicting academic anxiety. *Educational Psychology*, *42*(4), 479-500. https://doi.org/10.1080/01443410.2020.1729345

Zhang, J., Zhao, N., & Kong, Q. P. (2019). The relationship between math anxiety and math performance: A meta-analytic investigation. *Frontiers in Psychology*, *10*(1613). https://doi.org/10.3389/fpsyg.2019.01613

Živković, M., Pellizzoni, S., Doz, E., Cuder, A., Mammarella, I., & Passolunghi, M. C. (2023). Math self-efficacy or anxiety? The role of emotional and motivational contribution in math performance. *Social Psychology of Education*, *26*(3), 579-601. https://doi.org/10.1007/s11218-023-09760-8

APPENDICES

Appendix A: Sample ARCS Motivational Messages Used for This Study

Attention

- Welcome to our brief time together. Our goal is to supplement content your teacher presented.
- Please follow along with me to ensure you develop more understanding of the concepts.
- Please prepare yourself mentally by removing any distractions just like you would in class. Focusing your attention on our time together is key to success in any mathematics discussion.
- Thank you for watching this video.
- Notice this part of the question. You must remember this key step.
- Sometimes a common mistake occurs right here in the question.

Relevance

- Please note the examples that I will briefly cover. They are just as important as the examples your teacher covered today.
- You will need this to successfully understand your next lecture. Remember that mathematics builds on itself.
- Your upcoming test in the class will have problems like these.
- This type of question shows up in real-world situations.
- Your degree will require you to use this content in the future so understanding this now is crucial.
- I am excited to cover these concepts with you. I find this fun. I hope you also find it interesting to see how the numbers work together.
- If you maybe feel yourself getting frustrated with a question, remember that you are not alone in completing this task.

Confidence

- Following along with these examples will provide additional help to your understanding.
- As we work through these questions, evaluate your understanding and be willing to ask questions of your teacher.
- You can understand this question.
- Notice the following steps. Remembering the steps will permit you to apply the process to future questions.
- This easy-to-follow process you are learning will always work for these types of problems
- I am excited to cover these concepts with you. I find this fun. I hope you also find it interesting to see how the numbers work together.
- If you maybe feel yourself getting frustrated with a question, remember that you are not alone in completing this task. Your teacher and the textbook we use have been designed to help you.
- You should feel comfortable asking questions.

Satisfaction

- I know it is possible for you to successfully complete these problems.
- You can understand this question.
- Notice the following steps. Remembering the steps will permit you to apply the process to future questions.
- Successfully completing a question like this will help you to be prepared for future content.
- I am excited to cover these concepts with you. I find this fun. I hope you also find it interesting to see how the numbers work together.
- Be sure to check your work, if it matches what you see on the screen, then you have done the problem correctly.
- Our next problem will be like this one. I hope that your success in this question can help in the next one.
- If you thought this question was a bit more challenging, it was only because we needed to bring together multiple skills you already knew. It is a common skill in mathematics to analyze and apply with multiple skills.

Appendix B: Copy of Emailed Permissioned Use of the Instrument

Email exchange from Dr. Alexander granting permission to use the Revised Mathematics Anxiety Rating Scale in this study.

From: Alexander, Livingston <lalexand@pitt.edu>
Sent: Monday, December 12, 2022 9:39 AM
To: Bryant, Eric [redacted]
Subject: [External] Re: MARS test

Dear Mr. Bryant,

Congratulations on your progress towards completion of your doctoral work. I'm pleased to grant you permission to use the Abbreviated MARS for your dissertation research.

Best,

Livingston Alexander

From: Bryant, Eric [redacted]
Sent: Monday, December 12, 2022 3:28:16 AM
To: Alexander, Livingston <lalexand@pitt.edu>
Subject: Re: MARS test

Dr. Alexander,

It is good to speak with you again. I asked for your permission in 2013 to use your revised MARS for my doctoral dissertation. Although life has slowed down the process, I believe I am nearing the end of my work. My doctoral committee is strongly suggesting that I ask you again for permission to use your revised MARS since it has been almost 10 years since I asked you the last time.

I look forward to hearing from you.

Thank you,

Eric Bryant

RE: MARS test

Alexander, Livingston [redacted]

Fri 7/5/2013 10:50 AM

To:

- Bryant, Eric[redacted]

Eric,
You are hereby granted permission to use the revised MARS to advance your research. Good luck.
Livingston

Livingston Alexander
President
University of Pittsburgh at Bradford
300 Campus Drive
Bradford, PA 16701
814-362-7501
814-362-7690 (Fax)
[redacted]

From: Bryant, Eric [redacted]
Sent: Tuesday, July 02, 2013 12:10 AM
To: Alexander, Livingston
Subject: MARS test

Dr. Alexander,

I am a doctoral student at the beginning of my dissertation process at Liberty University in Lynchburg, VA. I am currently thinking that I would like to examine how an intervention would impact the mathematics anxiety and mathematics achievement of preservice elementary education majors.

I am writing to ask permission to use your revised version of the MARS test to check the mathematics anxiety of my participants.

If you would like to have more information about my proposed study, I can send that to you.

Thank you,

Eric Bryant

Appendix C: Instrument – Mathematics Anxiety Rating Scale - Revised

(Alexander & Martray, 1989)

Directions: For each of the following items, indicate how much the situation frightens you by circling the appropriate number. Use a five-point scale ranging from 1 (not at all) to 5 (very much).

	not at all				very much
1. Buying a mathematics textbook	1	2	3	4	5
2. Watching a teacher work on an algebraic equation on the blackboard	1	2	3	4	5
3. Signing up for a math course	1	2	3	4	5
4. Listening to another student explain a math formula	1	2	3	4	5
5. Walking into a math class	1	2	3	4	5
6. Studying for a math test	1	2	3	4	5
7. Taking the math section of a college entrance exam	1	2	3	4	5
8. Reading a cash register receipt after your purchase	1	2	3	4	5
9. Taking an exam (quiz) in a math course	1	2	3	4	5
10. Taking an exam (final) in a math course	1	2	3	4	5
11. Being given a set of numerical problems involving addition to solve on paper	1	2	3	4	5
12. Being given a set of subtraction problems to solve	1	2	3	4	5
13. Being given a set of multiplication problems to solve	1	2	3	4	5
14. Being given a set of division problems to solve	1	2	3	4	5

Directions: For each of the following items, indicate how much the situation frightens you by circling the appropriate number. Use a five-point scale ranging from 1 (not at all) to 5 (very much).

	not at all				**very much**
15. Picking up a math textbook to begin working on a homework assignment	1	2	3	4	5
16. Being given a homework assignment of many difficult problems that are due the next class meeting	1	2	3	4	5
17. Thinking about an upcoming math test one week before	1	2	3	4	5
18. Thinking about an upcoming math test one day before	1	2	3	4	5
19. Thinking about an upcoming math test one hour before	1	2	3	4	5
20. Realizing you have to take a certain number of math classes to fulfill requirements	1	2	3	4	5
21. Picking up a math textbook to begin a difficult reading assignment	1	2	3	4	5
22. Receiving your final math grade in the mail	1	2	3	4	5
23. Opening a math or stat book and seeing a page full of problems	1	2	3	4	5
24. Getting ready to study for a math test	1	2	3	4	5
25. Being given a “pop” quiz in a math class	1	2	3	4	5

Appendix D: Demographic Questionnaire

Name: ______________________

Date: ______________________

What is your gender? (circle one): Male / Female

How old are you? ________

What is your academic class standing?

1st year undergraduate (Freshman)

2nd year undergraduate (Sophomore)

3rd year undergraduate (Junior)

4th year undergraduate (Senior)

5th year undergraduate

Which race/ethnicity best describes you? (Please choose only one.)

American Indian or Alaskan Native

Asian/Pacific Islander

Black or African American

Hispanic

White/Caucasian

Multiple ethnicity/Other (please specify) __________

What is your college program of study?

Bible

Business

Computing

Criminal Justice

Early Childhood Education

Elementary Education

Engineering

English

History

Humanities

Interdisciplinary Studies

Mathematics

Music

Music Education

Natural Sciences

Nursing

Performance Studies

Secondary Education

Visual Arts

What is your approximate cumulative grade point average?

3.50-4.00

3.00-3.49

2.50-2.99

2.00-2.49

Below 2

Appendix E: Liberty University IRB Approval

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

April 3, 2023

Eric Bryant
Jeff Rector

Re: IRB Exemption - IRB-FY22-23-1075 The Effects of Motivational Messages on the Mathematics Anxiety of Pre-Service Elementary Education Majors

Dear Eric Bryant, Jeff Rector,

The Liberty University Institutional Review Board (IRB) has reviewed your application in accordance with the Office for Human Research Protections (OHRP) and Food and Drug Administration (FDA) regulations and finds your study to be exempt from further IRB review. This means you may begin your research with the data safeguarding methods mentioned in your approved application, and no further IRB oversight is required.

Your study falls under the following exemption category, which identifies specific situations in which human participants research is exempt from the policy set forth in 45 CFR 46:104(d):

Category 2.(ii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording).
Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation.

Your stamped consent form(s) and final versions of your study documents can be found under the Attachments tab within the Submission Details section of your study on Cayuse IRB. Your stamped consent form(s) should be copied and used to gain the consent of your research participants. If you plan to provide your consent information electronically, the contents of the attached consent document(s) should be made available without alteration.

Please note that this exemption only applies to your current research application, and any modifications to your protocol must be reported to the Liberty University IRB for verification of continued exemption status. You may report these changes by completing a modification submission through your Cayuse IRB account.

If you have any questions about this exemption or need assistance in determining whether possible modifications to your protocol would change your exemption status, please email us at irb@liberty.edu.

Sincerely,
G. Michele Baker, MA, CIP
Administrative Chair of Institutional Research
Research Ethics Office

Appendix F: Site Approval

From: Cochran, Raylene <rCochran@pcci.edu>
Sent: Thursday, April 13, 2023 5:22 PM
To: Bryant, Eric William <ewbryant2@liberty.edu>
Subject: [External] RE: Mathematics Anxiety Dissertation Project

You have permission to use our students for this study following the guidelines described below.

[redacted]
Academic Vice President
[redacted]

From: Bryant, Eric [redacted]
Sent: Thursday, April 13, 2023 2:56 PM
To: [redacted]
Subject: Mathematics Anxiety Dissertation Project

Dr. Cochran,

My name is Eric Bryant. I am in the dissertation stage of my doctoral program in Education at Liberty University in Lynchburg, Virginia. With your permission, I would like to ask your preservice elementary education students to participate in an experiment that will require them to watch 5 supplemental videos and complete an online questionnaire. The videos will be approximately 5 minutes each and the online questionnaire may take up to 30 minutes to complete. All students who participate will be part of a $25 Amazon gift card drawing. Your students' anonymity will be maintained, and only overall information will be shared with the institutions involved.

My dissertation proposal is The Effects of Motivational Messages on the Mathematics Anxiety of Preservice Elementary Education Majors. I seek to determine if a difference exists in the mathematics anxiety of preservice elementary education majors if they are provided mathematics content with and without motivational messages. These messages are based upon Pekrun's Control-Value theory and Keller's ARCS model of motivation. It is hypothesized because of these theories that motivational messages can help to reduce mathematical anxiety. The data I collect will help to understand if motivational messages provided by mathematics teachers can reduce the mathematics anxiety of preservice teachers. There are links in the literature to elementary teachers passing on their own mathematics anxiety so it is important to reduce the mathematics anxiety of preservice teachers so they don't pass this along to their students.

I look forward to hearing from you soon. You may call or email me. As soon as I get permission from Liberty's Institutional Review Board (IRB) to begin my experiment and data collection, I will be in contact again to coordinate involving your students. Thank you for your time.

Sincerely,

Eric Bryant

Appendix G: Professor Script

Read the following word-for-word on DATE to introduce the intention of the study, the participant responsibilities, the incentives for participation and instructions to complete the informed consent if the students wish to be participants in the study.

Hello Students,

As a graduate student in the School of Education at Liberty University, Eric Bryant is conducting research as part of the requirements for a Doctor of Education in Curriculum and Instruction degree. The purpose of his research is to test the influence of motivational messages on the mathematics anxiety of college students, and if you meet his participant criteria and are interested, he would like to invite you to join his study.

Participants must be 18 years of age or older and be enrolled in either EE 215 Arithmetic Skills for the Elementary School or MA 125 Mathematics for Liberal Arts at Pensacola Christian College during Spring 2023. Participants, if willing, will be asked to watch six videos (5 minutes each) that are coordinated to six classroom lectures and complete a survey (30 minutes) after watching all the videos. Names and other identifying information will be requested as part of this study, but the information will remain confidential.

Would you like to participate? If yes, Mr. Bryant needs to collect some information from you today to get started. If you would not like to participate, he understands. He is thankful for your consideration.

A consent document will be provided to you at this time. The consent document contains additional information about his research. If you choose to participate, you will need to sign the consent document and return it to me before you leave class today. Doing so will indicate that you have read the consent information and would like to take part in the study. Participants will be entered in a raffle to receive a $25 Amazon gift card.

Mr. Bryant would like to thank you again for your time and consideration.

Appendix H: Participant Consent Form

Consent

Title of the Project: The Effects of Motivational Messages on the Mathematics Anxiety of Pre-Service Elementary Education Majors
Principal Investigator: Eric Bryant, Doctoral Candidate, School of Education, Liberty University

Invitation to be Part of a Research Study

You are invited to participate in a research study. To participate, you must be a college student in the Preservice Education major, as well as enrolled in EE 215 Arithmetic Skills for the Elementary School or MA 125 Mathematics for Liberal Arts at Pensacola Christian College during Spring 2023. Taking part in this research project is voluntary.

Please take time to read this entire form and ask questions before deciding whether to take part in this research.

What is the study about and why is it being done?

The purpose of the study is to test the influence of motivational messages on the mathematics anxiety of college students.

What will happen if you take part in this study?

If you agree to be in this study, I will ask you to do the following:

1. Watch 5 supplemental videos that are approximately 5 minutes each for each lecture for two weeks of course lectures in addition to your regular homework assignments for your enrolled mathematics course. The supplemental videos will be delivered through Canvas.
2. Complete an online survey after the study is complete. This will take approximately 30 minutes.

How could you or others benefit from this study?

The direct benefits participants should expect to receive from taking part in this study include additional description and practice with course content during the time frame of the study.

Benefits to society include additional understanding of how college students receive mathematics instruction from their teachers.

What risks might you experience from being in this study?

The expected risks from participating in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

How will personal information be protected?

The records of this study will be kept private. Published reports will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records.

- Participant responses will be kept confidential by replacing names with pseudonyms.
- Hardcopy data will be kept confidential and stored in a locked file cabinet.
- Data will be stored on a password-locked computer/in a locked file cabinet. After three years, all electronic records will be deleted, and all hardcopy records will be shredded.

How will you be compensated for being part of the study?

Participants will be compensated for participating in this study. At the conclusion of the study, participants who watched all the supplemental videos and completed the online survey will be eligible for a drawing to receive one of seven $25 Amazon gift cards. You will be asked to provide your name and on-campus box number at the end of the survey.

Is the researcher in a position of authority over participants, or does the researcher have a financial conflict of interest?

The researcher serves as Chair of Education at Pensacola Christian College where the participants are enrolled. This disclosure is made so that you can decide if this relationship will affect your willingness to participate in this study. No action will be taken against an individual based on his or her decision to participate or not participate in this study.

Is study participation voluntary?

Participation in this study is voluntary. Your decision whether to participate will not affect your current or future relations with Liberty University or at Pensacola Christian College. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

What should you do if you decide to withdraw from the study?

If you choose to withdraw from the study, please contact the researcher at the email address included in the next paragraph. Should you choose to withdraw, data collected from you will be destroyed immediately and will not be included in this study.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Eric Bryant. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact him at [redacted]. You may also contact the researcher's faculty sponsor, Dr. Jeff Rector, at [redacted].

Whom do you contact if you have questions about your rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the IRB. Our physical address is Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA, 24515; our phone number is 434-592-5530, and our email address is irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University.

Your Consent

By signing this document, you are agreeing to be in this study. Make sure you understand what the study is about before you sign. You will be given a copy of this document for your records. The researcher will keep a copy with the study records. If you have any questions about the study after you sign this document, you can contact the study team using the information provided above.

I have read and understood the above information. I have asked questions and have received answers. I consent to participate in the study.

____

Printed Subject Name

____

Signature & Date

Appendix I: Participant Debriefing Statement for Control Group

Debriefing Statement

Title of the Project: The Effects of Motivational Messages on the Mathematics Anxiety of Pre-Service Elementary Education Majors
Principal Investigator: Eric Bryant, Doctoral Candidate, School of Education, Liberty University

Thank you for being part of a research study.

You recently participated in a research study. You were selected as a participant because you are a college student in the Preservice Education major, as well as enrolled in EE 215 Arithmetic Skills for the Elementary School or MA 125 Mathematics for Liberal Arts at Pensacola Christian College during Spring 2023. Participation in this research project was voluntary.

Please take time to read this entire form and ask any questions you may have.

What was the study about and why was it being done?

The purpose of the study was to test the influence of motivational messages on the mathematics anxiety of college students.

Why am I receiving a debriefing statement?

The purpose of this debriefing statement is to inform you that the true nature of the study or an aspect of the study was not previously disclosed to you.

You were originally told to watch supplemental videos as part of homework for the course. You were not told that your group did not receive supplemental videos with motivational messages.

Why was deception necessary?

Deception was necessary to see if a difference exists in the mathematics anxiety of preservice elementary education majors if they are provided mathematics content with and without motivational messages. These messages are based upon Pekrun's Control-Value theory and Keller's ARCS model of motivation. It is hypothesized because of these theories that motivational messages can help to reduce mathematical anxiety.

How will personal information be protected?

The records of this study will be kept private. Published reports will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records.

- Participant responses will be kept confidential by replacing names with pseudonyms.
- Hardcopy data will be kept confidential and stored in a locked file cabinet.
- Data will be stored on a password-locked computer/in a locked file cabinet. After three years, all electronic records will be deleted, and all hardcopy records will be shredded.

What should you do if you decide to withdraw from the study?

If you choose to withdraw from the study, please contact the researcher at the email address included in the next paragraph. Should you choose to withdraw, data collected from you will be destroyed immediately and will not be included in this study.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Eric Bryant. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact him at [redacted]. You may also contact the researcher's faculty sponsor, Dr. Jeff Rector, at [redacted].

Whom do you contact if you have questions about your rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the IRB. Our physical address is Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA, 24515; our phone number is 434-592-5530, and our email address is irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University.

Appendix J: Participant Debriefing Statement for Treatment Group

Debriefing Statement

Title of the Project: The Effects of Motivational Messages on the Mathematics Anxiety of Pre-Service Elementary Education Majors
Principal Investigator: Eric Bryant, Doctoral Candidate, School of Education, Liberty University

Thank you for being part of a research study.

You recently participated in a research study. You were selected as a participant because you are a college student in the Preservice Education major, as well as enrolled in EE 215 Arithmetic Skills for the Elementary School or MA 125 Mathematics for Liberal Arts at Pensacola Christian College during Spring 2023. Participation in this research project was voluntary.

Please take time to read this entire form and ask any questions you may have.

What was the study about and why was it being done?

The purpose of the study was to test the influence of motivational messages on the mathematics anxiety of college students.

Why am I receiving a debriefing statement?

The purpose of this debriefing statement is to inform you that the true nature of the study or an aspect of the study was not previously disclosed to you.

You were originally told to watch supplemental videos as part of homework for the course. You were not told that your group was given supplemental videos with motivational messages.

Why was deception necessary?

Deception was necessary to see if a difference exists in the mathematics anxiety of preservice elementary education majors if they are provided mathematics content with and without motivational messages. These messages are based upon Pekrun's Control-Value theory and Keller's ARCS model of motivation. It is hypothesized because of these theories that motivational messages can help to reduce mathematical anxiety.

How will personal information be protected?

The records of this study will be kept private. Published reports will not include any information that will make it possible to identify a subject. Research records will be stored securely, and only the researcher will have access to the records.

- Participant responses will be kept confidential by replacing names with pseudonyms.
- Hardcopy data will be kept confidential and stored in a locked file cabinet.
- Data will be stored on a password-locked computer/in a locked file cabinet. After three years, all electronic records will be deleted, and all hardcopy records will be shredded.

What should you do if you decide to withdraw from the study?

If you choose to withdraw from the study, please contact the researcher at the email address included in the next paragraph. Should you choose to withdraw, data collected from you will be destroyed immediately and will not be included in this study.

Whom do you contact if you have questions or concerns about the study?

The researcher conducting this study is Eric Bryant. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact him at [redacted]. You may also contact the researcher's faculty sponsor, Dr. Jeff Rector, at [redacted].

Whom do you contact if you have questions about your rights as a research participant?

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher, **you are encouraged** to contact the IRB. Our physical address is Institutional Review Board, 1971 University Blvd., Green Hall Ste. 2845, Lynchburg, VA, 24515; our phone number is 434-592-5530, and our email address is irb@liberty.edu.

Disclaimer: The Institutional Review Board (IRB) is tasked with ensuring that human subjects research will be conducted in an ethical manner as defined and required by federal regulations. The topics covered and viewpoints expressed or alluded to by student and faculty researchers are those of the researchers and do not necessarily reflect the official policies or positions of Liberty University.