THE EFFECTS OF AN ONLINE MATH INTERVENTION ON THE MATH ANXIETY LEVELS OF COMMUNITY COLLEGE STUDENTS

by

Rita Walter Love

Liberty University

A Dissertation Presented in Partial Fulfillment

Of the Requirements for the Degree

Doctor of Education

Liberty University

2018

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ABSTRACT

Finding an inexpensive, timely, and effective intervention to reduce math anxiety in community college students is a worthwhile endeavor. Math anxiety left unattended can lead to the conscious and deliberate avoidance of math-heavy educational programs and careers. Previous investigations in math anxiety interventions have overlooked the potential for mastery learning-based online modules to reduce math anxiety. The purpose of this two-factor quasi-experimental posttest-only control group study is to investigate whether participation in Let's Go Racing, a mastery learning-inspired intervention designed to prepare students for gateway math courses, affects math anxiety levels and whether the potential effect differs for male and female students. This study also seeks to determine if Strawderman's Math Anxiety Model and the reciprocal theory, both supporting the notion that student math success and math anxiety are inversely and bidirectionally associated, are plausible explanations of the phenomenon. A treatment group of Math 171 – Precalculus Algebra students at a small North Carolina community college was given the Math Anxiety Scale-Revised after completing Let's Go Racing, while a control group of Math 171 students from another North Carolina community college completed only the Math Anxiety Scale-Revised assessment. Data were collected electronically and analyzed using two-way ANOVA statistical analyses. Results support the notion that female college students experience higher math anxiety levels than their male counterparts. However, the impact of Let's Go Racing on math anxiety was inconclusive. The resulting recommendations are to replicate this study with a larger sample size and to investigate the effects of the Let's Go Racing math intervention in other math courses and with younger students.

Keywords: Let's Go Racing, mastery learning, math anxiety, math performance, reciprocal theory

Dedication

This work is dedicated to the Savior of my soul and Lord of my life, the God of this universe, who with unfathomable grace and mercy answered my repeated prayer that He "read through me" and "write through me" as I endeavored to earn a Doctor of Education degree. This same Holy creator, whose Word encourages us to complete our tasks for Him and not men (Ephesians 6:6-7; Colossians 3:22-23), worked out every step and schedule and brought all the right people into my life at just the right times to make this process the most challenging, fruitful, and character-building experience it could possibly be.

Those people are:

- the Walter Family "usual suspects," who have always prayed for me and celebrated my success;
- the two most beautiful women in the world, my mom and my sister; and
- my daddy, who has been my most enduring fan and biggest cheerleader.

Finally, there are no two more precious souls to me than my Jake and my John. Jake, about half-way through this doctoral journey, you entered the world kicking and screaming. You have made life interesting and purposeful, and we wouldn't have it any other way. John, your faith in my ability to finish this race has not waivered. You will never know how much this has meant to me and how essential you were to this achievement.

Acknowledgements

I would like to acknowledge and celebrate the patient and dedicated assistance of the following people:

- Dr. Nathan Putney (Dissertation Committee Chair – I highly recommend him to anyone searching for a dissertation committee leader.)
- Dr. Cynthia Dean (Committee Member – my co-worker with a keen eye for grammar and style, who also knows how to encourage the heart)
- Dr. David Barton (Committee Member – His laser-like focus on my analyses ensured that this project was well-planned, ethically implemented, and that the results were properly presented.)
- Dr. Scott Watson (Research Consultant – a very encouraging and highly knowledgeable instructor)
- Dr. Lois Smith and Carmen Elliot Nunalee, Esq. (These women were my direct supervisors during this process, and they never questioned my need for leave time from work to study, research, write, and travel to Lynchburg.)
- The staff of Second Street Sundries (Writing is much better in a quiet and cozy corner with an excellent cup of coffee by my side. These folks never disappointed.)

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List of Abbreviations

Brain-Computer Interface (BCI)

Let’s Go Racing (LGR)

Mastery Learning Theory (MLT)

Math Anxiety (MA)

Math Anxiety Assessment – Revised (MAS-R)

Personalized System of Instruction (PSI)

Programme for International Student Assessment (PISA)

Science, Technology, Engineering, and Math (STEM)

CHAPTER ONE: INTRODUCTION

Overview

The Christians at Philippi were warned to "be anxious for nothing, but in everything by prayer… let your requests be made known to God" (Philippians 4:6, New American Standard Bible). This verse encourages the reader to rely on the Lord when facing life's challenges. Community college students with math anxiety may find it difficult to comply with this passage of scripture, especially when involved in instructional or evaluative activities involving math. It may behoove higher education institutions to incorporate strategies that assist math-anxious students. Chapter One will discuss the background of math anxiety, including a brief history, characteristics, and important discoveries related to the condition. The problem statement will be discussed, as well as the significance of the current study. Finally, the research questions will be introduced, and definitions pertinent to this study will be given.

Background

Science, technology, engineering and math (STEM) careers comprise a varied and plentiful array of job titles, descriptions, and duties. The US has experienced a smaller pool of qualified STEM career candidates for these positions throughout the last three decades (U.S. Department of Education, 2008). Consequently, there has been an increased reliance on international candidates for American-based STEM positions (Andrews & Brown, 2015). One of the reasons U.S. college students avoid the STEM professions is the inextricable relationship of these careers to math (Hembree, 1990). Math is a key component of STEM careers.

However, the computation and application of numbers is not to be blamed for the decrease in student pursuit of math. Rather, math anxiety (MA), the anxiousness arising from the learning or performance of evaluative math exercises, is a primary contributor to math avoidance (Furner & Gonzalez-DeHass, 2011). Math anxiety also influences postsecondary education course selections (Tariq & Durrani, 2012). When students choose academic pathways that reduce their math anxiety triggers, they in effect choose careers that lead them away from math-heavy professional paths. As a result, even developed nations such as the US have experienced a smaller pool of qualified STEM career candidates (U.S. Department of Education, 2008).

Math anxiety affects many aspects of life beyond career choice. Vahedi and Farrokhi (2011) reported that MA is evidenced in the negative thoughts, performance inadequacy, feelings of pressure, and avoidance that result from being asked to perform calculations inside and outside the classroom. This debilitating nervousness with numbers may be one reason a majority of American adults have trouble with common computational tasks such as calculating tips, miles of travel per gallon of gas, and mortgage interest payments (Phillips, 2007). Studies as far back as the early 1970s focus on the characteristics, causes, effects, and measurements of MA. Richardson and Suinn (1972) distinguished MA from other forms of anxiety, defining it as "feelings… that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Richardson and Suinn (1972) also developed the Math Anxiety Rating Scale, the first of several instruments designed to assess the anxiety levels of individuals undergoing hypothetical math experiences. This significant research substantiated the existence of MA and sparked over five decades of associated study.

The prevalence of MA in postsecondary education students varies widely. Perry (2004) reported that 85% of his students claimed to have at least some level of math anxiety. Unfortunately for students with relatively high levels, this type of anxiety often leads to math avoidance. Math avoidance, presently defined as the conscious effort to avoid courses and programs that include mathematics in the curricula (Furner & Gonzalez-DeHass, 2011), is one of many consequences of MA (Brady & Bowd, 2005; Chipman, Krantz, & Silver, 1992). Other effects of MA include poorer math performance (Clute, 1984; Hembree, 1990) and decreased levels of learning (Cates & Rhymer, 2003). Math anxiety has also been reported to manifest itself in physiological ways such as a hypothalamic stress response to taking math tests (Sparks, 2011) and "increased heart rate, clammy hands, upset stomach, and lightheadedness" (Kelly, Rice, Wyatt, Ducking, & Denton, 2015, p. 174). Lyons and Beilock (2012) found the anticipation of math-related activities to be physically painful for some math-anxious individuals.

The varied effects of MA are less numerous than the suspected causes. Trujillo and Hadfield (1999) reported that the causes of MA can be categorized into one of three areas – environmental, intellectual, and personality. Environmental causes are those that are outside of the student's control, such as teaching style and parental pressure. Intellectual issues that may foster MA are personal characteristics such as lack of confidence and one's perception of how useful math is to personal and professional success. Personality-related sources of MA include character traits such as shyness but may also be related to feelings resulting from perceived gender stereotypes (Tobias, 1978).

A thorough study of MA must include its association with biological sex. In a regression analysis to determine predictors of MA for male and female college students, Haynes, Mullins, and Stein (2004) found that while male MA was associated with only two variables – math ACT scores and test anxiety – female MA had four predictors – math ACT scores, test anxiety, perception of high school math teacher methods and attitudes, and perceived math ability.

Wilder (2012) reported similar results, asserting that "The structure and nature of this condition are different for female and male students" (p. iii). The gender disparity is also evident in math avoidance, as women tend to study mathematics less than men (Drew, 2011).

Strawderman's (1985) Math Anxiety Model theorizes an explanation of MA by describing several domains that contribute to the phenomenon. Each domain incorporates a unique continuum of action or emotion. A student can be on any part of all three continua at a specific point in time. In other words, a person's MA level is the result of a combination of continua positions for each of the three domains at any given moment (Strawderman, n.d.). Movement along the Social/Motivational domain occurs along the Behavior continuum that ranges in action from *pursuit* to *avoidance*. The Psychological/Emotional domain is measured on the Feelings continuum with *confidence* and *anxiety* at its extremes. The final domain is the Intellectual/Educational domain, which ranges from *success* to *failure* along the Achievement continuum.

Strawderman (n.d.) posited that the more desirable ends of these continua (pursuit, confidence, and success) make up a positive cycle of behaviors and feelings that coincides with low MA. Conversely, the less desirable extremes (avoidance, anxiety, and failure) comprise the negative cycle, which is associated with higher levels of MA. Individuals may move from the positive to the negative cycle, and vice versa, via any one of the domain continua. The Intellectual/Education domain, measured on the Achievement continuum, is the primary domain of interest to the current study. If students are provided resources that help to position them closer to success and further away from failure, then they may approach the positive cycle, resulting in a decline in MA levels.

This supposition is supported by Carey, Hill, Devine, and Szucs (2015) in their reciprocal theory. Reciprocal theory suggests that the relationship between MA and math achievement is inverse and bidirectional. Not only does MA level influence math achievement, but math performance outcomes also affect levels of MA. The relationship between the two variables is inverse, meaning that as MA increases, performance decreases, and as performance improves, MA levels are lowered. Effective interventions that improve math performance outcomes may also help lower MA levels.

One such intervention, Let's Go Racing (LGR), is currently used in a North Carolina community college, but not for the purposes of reducing MA. Let's Go Racing is a set of online modules designed to help ensure that students have all the prerequisite skills needed to learn successfully the concepts of their particular gateway math courses (Myers, Bowman, Smith, & Love, 2016). Following the principles of Bloom's (1971) mastery learning theory, LGR includes an initial assessment called *Start Your Engines*, the results of which determine the current skill level of the student. Based on pre-test results, instructional and practice opportunities called *Pit Stops* are provided so that the student can review and practice skill areas of weakness. Finally, the *Winner's Circle* is a posttest that informs the student and course instructor of the student's gateway math readiness.

The preliminary reports of higher student success rates when LGR is used suggest that the modules are a promising intervention for improving student success (Myers et al., 2016). Both Hembree (1990) and Carey et al. (2015) described an inverse relationship between math anxiety and success. Since MA is inversely related to math success, and LGR has been shown to improve math success, it is conceivable that LGR may be boosting student success via a mitigating factor of MA reduction. In other words, the online remediation modules may improve math performance, at least in part, because of their ability to reduce MA.

Problem Statement

Various theory-based interventions have been designed and studied to determine their abilities to reduce MA. Applying Bandura's self-efficacy theory, Alcindor (2015) tested an intervention that included efficacy-building and math anxiety (MA) management activities with preservice elementary and special education teachers. She noted improvements in mathematical learning, but no significant effect on math self-efficacy or MA. Harding (2015) studied the utility of cooperative learning groups to reduce MA in college math classes. Grounded in Vygotsky's social learning theory and Piaget's peer learning theory, the intervention lowered MA with a more profound effect on females than males. Social cognitive theory served as the framework for Zeleny's (2013) research on journaling as a successful method to reduce anxiety in university math class students. Similarly, Sgoutas-Emch and Johnson (1998) reported that journaling reduced anxiety for students in an undergraduate statistics course. Testing an amalgam of Piaget's cognitive development theory, Vygotsky's sociocultural theory, and Bandura's self-efficacy theory, Orabuchi (2013) studied the effects of an online and interactive technological tool as part of math instruction in sixth-grade classrooms and found a statistically significant difference in MA between the intervention and control groups.

Published experimental studies that investigate the effects of online modules preparation programs on the MA levels of postsecondary students is minimal. However, an intervention for MA reduction in community college math students may have already been developed but is not yet reported in the literature. Let's Go Racing, online tutorial modules designed to assess, teach, nurture practice, and re-assess, may be effective preparatory tools for student math course success, because they may help to reduce the MA levels that otherwise hinder learning (Tobias, 1978). The problem is that these mastery learning-based course preparation modules that have been shown to improve math course success, have not been studied with respect to their effects on MA in community college students. This gap in the literature will be addressed by the current study.

Purpose Statement

The purpose of this study is to investigate the effects of Let's Go Racing (LGR) participation on the MA levels of community college students and analyze results to determine if LGR impact on MA differs for males and females. The process will explore one of the three constructs that comprise Strawderman's (n.d.) Model of Math Anxiety – the Intellectual/Educational domain measured on the Achievement continuum – and the mutually influencing relationship between MA and math performance posited by the reciprocal theory (Carey et al., 2015). The effects of the LGR online instructional modules, fashioned from the principles of mastery learning theory, will be studied in a two-factor quasi-experimental, posttest-only control group design. The independent variables under study are the status of LGR module participation as part of a Math 171 – Precalculus Algebra course and biological sex. The dependent variable is the mean levels of math anxiety for the treatment and non-treatment groups, as determined by the Math Anxiety Scale – Revised (Bai, Wang, Pan, & Frey, 2009).

Significance of the Study

The current study will investigate the practical application of Strawderman's (n.d.) Model and the Carey et al. (2015) Reciprocal Theory. It will also provide insight into the ability of the Let's Go Racing (LGR) online modules to reduce the math anxiety (MA) and fear of math that hinder learning (Prevatt, Welles, Li, & Proctor, 2010), reduce course success (Hembree, 1990), and ultimately foster the avoidance of math (Ashcraft & Krause, 2007; Brady & Bowd, 2005) and STEM careers (Drew, 2011). The benefit of MA reduction is multi-tiered, impacting individuals, institutions, and economic systems. When students participating in an intervention experience a repositioning toward the s*uccess* end of the Strawderman (1985) Math Anxiety Model Achievement continuum, lowered MA levels may result. Students can then learn additional mathematical concepts, experience greater success in math courses, and make course and career choices that are not limited by the degree of math involved.

Math anxiety can take root as early as the fourth grade (Dutko, 2015; Ma, 1999). Attempts to prevent MA, and treatments to ameliorate its effects throughout the primary, middle, and high school years have been extensively studied. Some of these treatments are recommended as best practices in teaching (Furner & Duffy, 2002; Orabuchi, 2013; Verkijika & Wet, 2015). However, when MA persists in students after high school, it becomes necessary to assist them with MA-reducing resources at the college level (Zientek, Yetkiner, & Thompson, 2010). Interventions must be practical, efficient, and inexpensive, especially with respect to community colleges and other higher education institutions that operate with limited funding. Let's Go Racing meets these criteria and may serve to minimize the effects of math anxiety in community college students.

Research Questions

The following research questions are proposed for this study:

RQ1: Is there a difference between the mean math anxiety scores of community college students based on online math module participation?

RQ2: Is there a difference between the mean math anxiety scores of community college students based on biological sex?

RQ3: Is there an interaction effect between online math module participation and biological sex on the mean math anxiety scores of community college students?

Definitions

An understanding of the following terms is crucial to the interpretation of the current study:

1. *Gateway math courses* – Entry-level math courses for which successful students earn transferable college credit. This does not include developmental math courses, as they do not provide transferable credits in the system under study. At the study sites, the three gateway math courses are Math 143 – Quantitative Literacy, Math 152 – Statistical Methods I, and Math 171 – Precalculus Algebra (*College Catalog Student Handbook*, 2016).
2. *Let's Go Racing (LGR)* – A math skills intervention comprised of online modules in which gateway math course prerequisite skill readiness is assessed, addressed with instructional activities, and re-assessed with a posttest instrument. The primary goal of the Math 171 version of LGR is to ensure that students have the prerequisite knowledge needed to begin study of precalculus algebra concepts (Myers et al., 2016).
3. *Mastery learning theory (MLT)* – Theory based on the belief that all students can learn if given sufficient time and conditions. Instructional application of MLT includes assessments, instruction based on assessment results, followed by formative assessment designed to ensure that students have mastered all necessary concepts to continue to more advanced information (Bloom, 1971).
4. *Math 171 – Precalculus Algebra* – One of three gateway math courses offered to degree-seeking students at North Carolina community colleges. Upon completion of the course,

students are “able to select and use appropriate models and techniques for finding solutions to algebra-related problems” (*College Catalog Student Handbook*, 2016, p. 214).

5. *Math anxiety* – “A feeling of tension, apprehension, or fear that interferes with math performance” (Ashcraft, 2002, p. 181) “in a wide variety of ordinary life and academic situations” (Richardson & Suinn, 1972, p. 552).
6. *Math avoidance* – Efforts to avoid encounters with “mathematics-related activities, such as choice of majors or choice of careers that involve mathematics” (Pinnock, 2014, p. 189).

CHAPTER TWO: LITERATURE REVIEW

Overview

Math anxiety (MA) has been studied with respect to age group, racial ethnicity, and biological sex since it was first identified and officially named in the 1970s. Though the causes, components, and processes have yet to be understood fully, numerous and varied treatments and interventions have been examined for their capacities to prevent or treat the condition (Dowker, Sarkar, & Looi, 2016; Furner & Duffy, 2002). Math anxiety impacts student decisions regarding academic programs and careers, often resulting in math avoidance (Tariq & Durrani, 2012), rendering it beneficial for incoming college freshmen to have access to MA-reducing programs. The purpose of this study is inspired by the idea that an online, mastery learning-based preparatory program that is believed to have improved success rates in community college gateway math courses, may also have an impact on student math anxiety.

Conceptual Framework

Informed by the principles of mastery learning theory (Block & Burns, 1976; Bloom, 1968), Let's Go Racing (LGR) is an online, mastery learning-based intervention designed to ensure that students in community college gateway math classes possess the prerequisite knowledge necessary to learn the concepts of the gateway math courses for which they have enrolled. A gateway math course is the first curriculum credit college math course completed as part of a student's program of study. This does not include remedial math courses, which some students may be required to take before they are proficient enough to take curriculum credit courses.

Let's Go Racing was developed to increase student success, but its potential to reduce math anxiety (MA) at the inception of a gateway course is rooted in reciprocal theory, a relatively recent conjecture that attempts to explain the cyclical relationship between math achievement and MA (Carey et al., 2015). Strawderman's (1985) math anxiety model – specifically, the relationships among student understanding, academic success, and MA – also implies that high MA levels are bidirectionally associated with math failures, and low MA levels are bidirectionally associated with student success. Mastery learning theory, Strawderman's math anxiety model, and reciprocal theory are described in this section.

Mastery Learning Theory

Bloom's (1968) Learning for Mastery may have come to prominence in educational research and practice during the 1960s and 1970s, but the groundwork for its principles was established much earlier in the 20th Century (Kulik, Kulik, & Bangert-Drowns, 1990). Washburne and Marland (1963) reported that in certain instructional systems, students in the second and third decades of the 1900s were required to demonstrate lesson mastery before advancing to new material. These preliminary buds of what would be one of the most influential educational theories in American practice (Marshall, 2016; Siddaiah-Subramanya, Smith, & Lonie, 2017) would blossom over the next century.

A description of mastery learning theory's (MLT) basic principles will help the reader understand its divergence from conventional instruction in which students are exposed to new knowledge regardless of their level of understanding of previous lesson objectives. The central notion of MLT is that all students can learn most of the information they are taught, if the instructional conditions are appropriate to their needs (Block, 1972). More specifically, students can master the material, an endeavor Ambrose, Bridges, and DiPietro (2010) defined as "the attainment of a high degree of competence within a particular area" (p. 95). The goal of mastery learning-based instructional design is to provide instruction in a way that provides students at all ability levels the opportunity to learn the educational objectives to a degree at which they can move forward to more advanced concepts or skills.

To meet this challenge, MLT instructs educators to complete four actions. They are to define mastery, plan for mastery, teach for mastery, and grade for mastery (Block & Burns, 1976). Each of these actions is important to Bloom's learning for mastery concept, which established the mastery learning movement in primary and secondary schools in the latter part of the 1960s (Anderson, 1994). They are also the central components of Keller's personalized system of instruction, a mastery learning model fashioned to the needs of postsecondary students (Keller & Sherman, 1974). Regardless of the target audience, the practical application of MLT components consists of the following four steps:

- Specify course objectives.
- Break the course into smaller units.
- Teach each unit for mastery.
- Evaluate the student's mastery over the whole course. (Block & Burns, 1976)

Mastery Learning Theory sparked a revolutionary way of teaching in the mid- to late-1900s, leading to numerous studies regarding its ability to improve student cognitive skills (Born & Davis, 1974; Garver, 1998; Mevarech, 1986) and its effects on non-cognitive factors such as attitude and self-concept (Ferguson, 1981; Morris & Kimbrell, 1972). With most studies showing positive effects (Kulik et al., 1990) on student achievement and affective characteristics, educational researchers began to focus on delineating how and why mastery strategies worked so well. Characteristics such as student preparedness or readiness (Fiel & Okey, 1975) were investigated against the backdrop of mastery learning components. Breadth of instructional objectives, learning unit size, and the standards of what indicated mastery surfaced as the necessary pieces for effective mastery learning application (Block, 1972). More recent studies of MLT implementation in a wide variety of educational and training arenas support the notion that the theory continues to inspire teaching and learning (Buch, Nerstad, & Safvenbom, 2017; Sabani, Hardaker, Sabki, & Salleh, 2016; Yudkowski, Park, Lineberry Knox, & Ritter, 2015).

A review of student characteristic and MLT component studies led Block and Burns (1976) to believe "the reason the unit mastery requirement and the meeting of that requirement have exerted such an influence over student learning is because they have affected the quality and quantity of student study time" (p. 35). The current study will emphasize the importance of student study time quality over study time quantity, as Let's Go Racing, the intervention under study, has a relatively short duration. Students can complete the modules within 10 hours or less, though they may choose to do so in one day or over several days (B. Myers, personal communication, April 11, 2017). While the amount of time required to complete LGR is minimal, its mastery learning principles focus the instruction on those areas in which the student needs remediation.

Despite the apparent success of MLT application, the theory retained its share of controversy. Bloom and Keller experienced vehement criticism from one particularly passionate critic. Slavin (1987) debunked the conclusions of two meta-analyses that indicated group-based mastery learning programs were effective. His conclusion of the research by Kulik, Kulik, and Bangert-Drowns (1986) and Guskey and Gates (1986) was that although moderate improvements were evident in student success when locally-made assessments were used, there was no evidence of improved student achievement when standardized tests were utilized. Slavin (1987) further claimed that any academic gains attributable to MLT curricula were temporary and not necessarily retained over time.

These criticisms only pertained to elementary and secondary school intervention studies, but they were extensive and critical enough to provoke a response from Bloom (1987). After reminding readers that MLT had been applied internationally for 19 years, Bloom rebutted his critic. First, he provided a detailed explanation of the importance of the feedback-corrective process when mastery learning principles are implemented, asserting that some of Slavin's (1987) referenced studies were not investigating truly MLT-based programs. Second, Bloom specifically addressed Slavin's criticism that success was only evident in student performance on experimenter-made assessments and that standardized instruments indicated MLT had no better results than conventional instruction. Bloom (1987) contended that this is to be expected since "experimenter-made tests more accurately measure the intended objectives of the teaching than does a standardized measure" (p. 507). Additionally, he reported that longitudinal studies of MLT application showed higher levels of standardized test performance.

Three years later, Slavin (1990) responded to Bloom and addressed updated versions of the controversial meta-analyses. Slavin indicated that in some of the studies the curriculum was not held constant between experimental and control groups. He also pointed out that the effect sizes of MLT interventions varied widely for experimenter-made and standardized assessment scores within the same study. Therefore, Slavin refused to acquiesce that mastery-based practices positively affected student achievement on standardized measures. However, he did relent that MLT can be helpful to instructors who are focused on certain local objectives. This acknowledgement is relevant to the current study, as the primary goal of each version of Let's Go Racing is student readiness for a specific gateway math course.

Despite palpable controversy, both prominent MLT applications, learning for mastery and personalized system of instruction, continue to influence educational practice. First, a recent comparison of MLT to contemporary Islamic pedagogy affirms this, as similarities were noted in the methodologies. Both tout the importance of movement at one's own pace toward mastery, practicing what has been learned in order to reach mastery, and a personalization of the learning experience (Sabani et al., 2016). Second, medical educators Yudkowsky et al. (2015) called for a transformation of medical school curricula to incorporate mastery learning principles that would improve "the effectiveness of health professions education, patient safety, and patient care" (p. 1495). Finally, military academies throughout Norway have recently established a mastery learning climate for cadet training (Buch et al., 2017).

While incorporation of MLT ideas into various educational and training sectors provides a persuasive argument for the popularity of mastery learning, evidence-based successes may be more convincing of its effectiveness. Specific examples of mastery learning programs that have produced improvements in student learning and success are described here, so that the reader may understand the utility of mastery learning principles. These examples are presented in the following three sections, classified based on instructional delivery characteristics – face-to-face programs, electronic learning (e-learning) programs, and math education programs.

Face-to-face programs. Present-day programs based on mastery learning principles are numerous and varied. This is not surprising, as Levine (1985) asserted during the boom of MLT intervention research that if the general prescriptive steps are included, mastery-based practice offers flexibility and applicability to myriad subject areas. For example, the results of a case study of a mastery learning-based intervention in a university art education course encouraged the investigator to continue the practice in future courses (Sinner, 2015). The mastery-based inclusions did not limit creativity, but rather helped establish a framework of course goals.

Demonstrating the value of MLT on a more long-term scale, the University of Maryland Eastern Shore School of Pharmacy utilizes a mastery learning approach throughout its three-year pharmacist training program. Students are instructed in two-week blocks for which end-of-block assessment determines whether students can progress to the next block. Mastery level is set between 75% and 85%, depending on course type (Tejada, Parmar, Purnell, & Lang, 2016).

Another example from healthcare education is the emphasis on MLT utilization in nursing program simulation instruction. Adamson (2015) reviewed 153 studies of nursing education simulation programs. Her findings suggest that "competency-based educational strategies with standardized outcomes" (mastery learning; p. 284) combined with deliberate practice improve skill performance in nursing students. More recently, Gonzalez and Kardong-Edgren (2017) encouraged educational practitioners to blend mastery learning theory with deliberate practice for the dual purposes of helping nursing students acquire new skills and to help prevent the loss of previously learned skills.

Similarly, Schellhase (2008) explained that athletic training programs have deep historical roots in mastery learning practices. However, over time the incorporation of MLT practices has diminished. Schellhase argued that a return to mastery learning is a necessary step in athletic trainer education reform.

E-learning programs. When Bloom (1968) and Keller (1974) put forth their learning for mastery and personalized system of instruction (PSI) theories, respectively, they could not have known how these ideas would be fashioned for use with 21st-Century technology. Mastery learning theory and e-learning have meshed well, namely because e-learning is not limited by time and space (Lin, Huang, & Hwa, 2011). This is an important feature for mastery-based curricula, as students are encouraged to use as much time as needed to master each lesson (Block

& Burns, 1976). In a flipped classroom, which includes a blend of seated and online components, Liu, Wei, and Gao (2016) found that the online assessment and feedback (essential MLT components) provided to English language learners allowed them to progress into appropriate micro-courses based on ability. This not only tailored instruction to fit the learner but also increased student learning.

Another example of a web-based PSI application is the Rae and Samuels (2011) experimental study of an introductory discrete mathematics course. Students in the experimental group – those who received mastery-based education in a virtual learning setting – showed higher cognitive achievement than those in the control group. The authors touted mastery learning as effective for postsecondary online instruction. Similarly, regarding a variation of e-learning educational practice called game-based instruction, Yang (2017) argued that while this new form of pedagogy may hold the interest of students, the students may not master or retain the lesson information and concepts. However, integrating mastery learning principles in an e-learning, game-based environment can result in the same student performance levels as the traditional teacher-present format (Yang, 2017). In other words, when MLT is incorporated into different types of e-learning instruction, at least some of the missing advantages of face-to-face interaction are mitigated.

Math education. While mastery learning continues to provide a foundation for educational practice across the gamut of instructional delivery methods, it is particularly important to the present study to highlight MLT practices in mathematics education. One example is found in the mastery learning-based math emporium model in which math students use computer-based learning resources. While a teacher is present for questions and supplemental instruction, the majority of the instruction is delivered through an e-learning program (Twigg, 2011). A study of math emporium versus the traditional education practice for a group of high school algebra students showed no significant difference in resultant knowledge. However, when assessed approximately six weeks after the end of the algebra course, students in the emporium setting demonstrated a greater retention of knowledge compared to their traditional education counterparts (Wilder & Berry, 2016).

Mastery learning in the form of instructional modularization has gained popularity in developmental math program redesign efforts (Ariovich & Walker, 2014). In one study, students and faculty members reported advantages and disadvantages to the relatively new approach. Additionally, quantitative measures of student success indicated that students in modularized courses fared worse than those in traditional instruction classes – those that incorporate direct instructional methods that are indifferent to learning pace or concept mastery (Ariovich & Walker, 2014). However, Dorfman (2014) found that computer-mediated instruction that incorporated mastery learning pedagogy yielded higher success rates than traditional seated lecture instruction for developmental math students at a large university. Furthermore, results from a study of best practices in a state-wide community college system suggested that developmental math programs should incorporate mastery learning along with collaborative and cooperative learning methodologies (Butler, 2014). Butler went on to suggest that this type of developmental math education could be used for other purposes, such as “math refresher workshops, bridge programs, and co-requisite courses to college-level math” (p. ii). These conclusions are strengthened by the results of Bradley’s (2016) quasi-experimental investigation of 529 developmental math students. In this study, the mastery learning group excelled in comparison to the traditional method instruction group. Positive effects were noted in both current course concepts acquisition and subsequent math course success.

Math Anxiety Model

Although the causes, effects, and measurement of math anxiety (MA) had been extensively studied, it was not until the mid-1980s that a comprehensive model was developed to explain the phenomenon. Strawderman (1985), who already held a Doctor of Philosophy degree in Mathematics, dedicated her Doctor of Education program dissertation to the task. Strawderman designed an integrative model based on the primary categories of MA causes – student personality, current math situation, and previous environment of the student (Byrd, 1982). These correlate with three affective domains – Social/Motivational, Psychological/Emotional, and Intellectual/Educational – which Strawderman believed to have influenced the learning continuum that ranges from rote memorization to understanding. The extreme ends of these domains are associated with either high or low MA.

Strawderman (1985) tested her assumptions in a group of 390 entry-level university students using self-reporting instruments of perception. Three of these assessment questionnaires were developed and piloted for the study, and one was validated previously in the literature. These instruments were consolidated into one 48-item questionnaire, and participant scores were then analyzed using regression analysis with MA as the dependent variable. All independent variables (perceived level of understanding, perceived level of achievement, and willingness to engage in mathematics) were highly associated with each other and were directly correlated to confidence in mathematics. Conversely, rote memorization of material correlated significantly with high MA, failure, and math avoidance.

Figure 2.1 is Strawderman's (1985) diagram of the math anxiety model. The centrally-located Cognitive domain, which indicates the degree of true learning and understanding, is depicted as a continuum, ranging from "Rote Learning" to "Understanding."

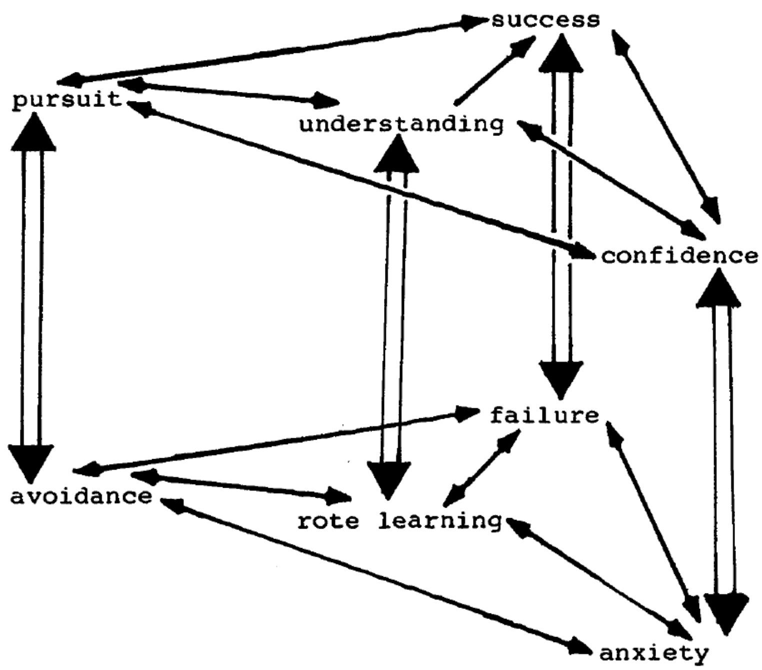

Figure 2.1. Model of Math Anxiety. Reprinted from *A Description of Math Anxiety Using an Integrative Model* (p. 144), by V. W. Strawderman, 1985, Ann Arbor, MI: University Microfilms International. Copyright 1985 by V. W. Strawderman. Reprinted with permission (Appendix A).

Each of the three surrounding affective domains contains a unique continuum. These include

- the Social/Motivational domain, measured on the Behavior continuum that ranges from pursuit to avoidance,
- the Psychological/Emotional domain, measured on the Feelings continuum that ranges from confidence to anxiety, and
- the Intellectual/Educational domain, measured on the Achievement continuum that ranges from success to failure.

Strawderman (n.d.) posited that the more desirable ends of these continua (pursuit, confidence, and success) make up an interconnected web of behaviors and feelings associated with low MA. Students have positions on all three affective continua, and their MA levels and degrees of learning are associated with these positions.

Though Strawderman's (1985) model is rarely referenced in MA literature, researchers have published articles aligning with her assertions that MA possesses various interconnected components. Pletzer, Wood, Scherndl, Kerschbaum, and Nuerk (2016) attempted to clarify the complicated factor structure of MA, admitting that "mathematics anxiety is rather a multidimensional than unique construct" (p. 1). In a summation of what was known about MA at the time, Ashcraft (2002) recognized that to understand MA, more needed to be learned about its emotional and cognitive properties. Prior to Strawderman's work, Spielberger (1972) shared that anxiety was much more than an emotion, because it also encompassed physiological and experiential properties. Finally, Wigfield and Meece (1988) asserted that MA has at least two separate dimensions – the cognitive and the affective.

Strawderman's (1985) diagram indicates that MA truly is multifaceted. The components most pertinent to the current study are the different arrows of influence shown between the positive continua extremes (Figure 2.1). A bidirectional association exists between the affective descriptors, except for the "success" and "understanding" relationship. For the most part, each of these associations mutually influences each other. For example, as confidence increases, understanding, math pursuit, and success also increase. The gains in understanding, math pursuit, and success are then translated into improvements in confidence. The interjection of an intervention into one of these cycles of repeated influence, and its resulting effects on MA are the crux of the current study. However, a more specific theory pertaining to MA and math achievement must first be discussed.

Reciprocal Theory

Strawderman's (1985) model highlights many contributing factors to math anxiety (MA). The current study is focused particularly on one of these areas of influence – student achievement in mathematics, also referred to as student performance or student success. Reciprocal theory addresses the seemingly contradictory evidence regarding the relationship between student success and MA. The topic of much educational and psychological research, the conundrum here is whether MA causes decreased student performance (debilitating anxiety model), or whether decreased student performance influences MA levels (deficit theory).

Debilitating anxiety model. The debilitating anxiety model proposes that low math performance is the result of "anxiety's devastating consequences on learning and recalling maths skills" ("The Relationship Between," n.d., para. 6). The results of an early study of the relationship between MA and math performance in middle schoolers hint that while perceived performance was significantly related to MA, actual performance was not (Meece, Wigfield, & Eccles, 1990). This would suggest that MA is not a strong predictor of math success. However, numerous studies support the idea that high levels of MA are a major contributor to underperformance in math activities and that low MA contributes to high math achievement across age levels.

As early as primary school, math anxiety has been shown to have an effect on math achievement. In a regression study of second and third graders, Wu, Barth, Amin, Malcarne, and Menon (2012) demonstrated that high math anxiety had deleterious effects on student performance in mathematical reasoning and numerical operations. In a group of eighth graders, Hafner (2008) found that MA significantly predicted math achievement, and that this inverse relationship was mediated by student math self-efficacy. Nunez-Pena, Suarez-Pellicioni, and Bono (2013) studied the effects of MA and other factors, such as self-confidence and enjoyment of mathematics, on university student performance in a research design class – a course that contains high math content. Multiple regression analyses led authors to conclude that MA was the most influential factor on student performance. Students with high levels of MA tended to have lower exam grades, and students with low math anxiety achieved higher exam grades (Nunez-Pena et al., 2013).

Deficit theory. The deficit theory, as it pertains to MA and math performance, implies that poor performance in past math activities generates math anxiety in subsequent math-related events (Devine, Fawcett, Szucs, & Dowker, 2012). Essentially, a lack of math success brings forth situation-specific psychological consequences. Studies supporting that math anxiety is driven by a deficit in math achievements include:

- a longitudinal study of adolescents in which structural equation modeling indicated that for high school juniors and seniors, low-achieving students subsequently experienced higher MA levels (Ma & Xu, 2004);
- a predictive correlation investigation of the ability of multiplication fact fluency to predict math anxiety levels in elementary school students, which yielded that this prior achievement is a statistically significant predictor of MA level (Dutko, 2015); and
- a two-year longitudinal study of Finnish high schoolers showing that "prior low achievement in mathematics seems to predict later anxiety in mathematics" (Kyttala & Bjorn, 2010, p. 442), although prior math success only indirectly affected subsequent anxiety. Student outcome expectations may have mediated this effect.

Erturan and Jansen (2015) provided additional support for the presence of a mediating factor between math success and subsequent low MA. These authors reported that it is actually a student's perceived math confidence, most likely resulting from previous math success, which brings about lower MA. Consequently, it is reasonable to suspect that low math confidence can result in higher MA.

Reciprocal theory. Reconciling seemingly contradictory findings from studies supporting either the debilitating anxiety model or the deficit theory, Carey et al. (2015) proposed the reciprocal theory. These authors asserted that a bidirectional relationship exists between MA and student performance in math. Like the math anxiety model cycles suggested by Strawderman (1985), reciprocal theory implies a perpetual synergy of mutual influence between math performance and MA. In a follow-up study to their 2015 reciprocal theory introductory article, Carey, Devine, Hill, and Szucs (2017) attempted to parse out the effects of other anxieties on the relationship between MA and math performance. Results suggested that general anxiety had fewer deleterious effects on academic performance than test and math anxiety. More importantly for reciprocal theory, the investigators found their results to support evidence of a cyclical relationship between MA and math performance. Furthermore, Foley et al. (2017) reviewed math performance-math anxiety studies alongside Program for International Student Assessment data. Their conclusions were that the reciprocal theory satisfactorily explains the relationship between MA and math performance. The authors also suggested that researchers consider the performance-anxiety bidirectional relationship when developing MA-reducing interventions, whether they are implemented to help prevent MA such as parent or teacher training designed to prohibit the transmission of math anxiety from the adult to the student, or to treat the condition such as one-on-one math instruction.

Though a relatively new concept given the 60-year history of MA study, reciprocal theory has served as a theoretical influence in several subsequent studies. For example, in the successful revision and validation of the Math Anxiety Scale for Young Children (MASYC), Ganley and McGraw (2016) cited the importance of a likely bidirectional relationship between math performance and MA. This, along with other MA correlates such as math confidence and math interest, were considered as new MASYC instrument items and were developed and tested. A second example is provided in a prevalence study of MA among students in a British university business school. Howard and Warwick (2016) found that levels of MA did not vary by gender or age, but rather by level of study (bachelor's degree versus a certificate program), one level providing more math experience than the other. The authors referred to the necessary consideration of the bidirectional math performance-MA relationship when designing interventions to assist business students with high MA. Finally, Sung, Chao, and Tseng (2016), in their study of the relationship between test anxiety and achievement, claimed their results that anxiety was positively related to math achievement for some students did not conflict but rather supplemented the work of Carey, et al. (2015). Their reasoning was that their study considered the effects of stress from uncertainty, allowing more of a macro-level view of how anxiety and performance are related (Sung et al., 2016).

The reader should note that reciprocal theory does not concern itself with all of Strawderman's (1985) contributors to MA, but instead focuses only on the two-way relationship between MA and the Achievement Continuum that ranges from "Failure" to "Success." An intervention that provides opportunities for student success could therefore have an impact on MA, which in turn could improve student success, continuously repositioning the student toward the high achievement/low MA extreme of the model. This idea is illustrated in Figure 2.2. The diagram serves as a visual demonstration of how the effects of a mastery learning theory-based intervention may be beneficial, extensive, and enduring. The synergistic effects of increased student success and lowered MA may persist indefinitely.

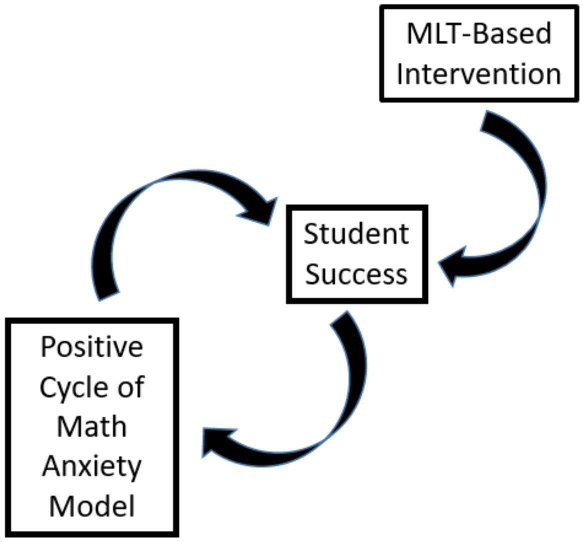

Figure 2.2. A model of the expected influence of a mastery learning-based intervention on student success and math anxiety.

Heller and Cassady (2017) studied the ability of general academic anxiety to predict overall student success in community college students. Their results indicated that no significant predictive relationship existed, as environmental factors tended to have more influence on student success. However, the lack of relationship between general academic anxiety and student success does not disqualify the potential for a direct correlation between MA and math course success. The nature of MA differs from that of general academic anxiety, and the results of numerous studies have supported the underlying principles of the math anxiety model and reciprocal theory (Ashcraft & Faust, 1994; Hembree, 1990; Luo et al., 2014; Ma, 1999; Ma & Xu, 2004).

Related Literature

Math anxiety (MA) has been defined, measured, blamed, and treated for almost 60 years (Chernoff & Stone, 2014). Its physiological, academic, and social effects on individuals, and its impact on the American science, technology, engineering, and math (STEM) workforce, have been a concern for educators, psychologists, policy-makers, and employers (Beilock & Maloney,

2015) since the first hints of MA differentiation from general anxiety (Aiken, 1963, 1970). Cost-effective treatments and interventions can have a pervasive impact on MA and career choice. Current issues regarding MA and the potential for Let's Go Racing (LGR) to alleviate MA in community college students are discussed here.

Current Trends

Still defined in brief as "fear or apprehension about math" (Foley et al., 2017, p. 52), math anxiety (MA) continues to permeate the literature as investigators search for causes (Boaler, 2014; Wang et al., 2014), physiological indicators (Suarez-Pellicioni, Nunez-Pena, & Colome, 2016; Young, Wu, & Menon, 2012), individual and social consequences (Andrews & Brown, 2015; Williams & Davis, 2016), and treatments (Feng, Suri, & Bell, 2014; Harding, 2015; Kelly et al., 2015). Over five decades of research have yet to result in treatments and best practices that resolve the impact of MA on student learning and evaluation. To fully grasp the importance of the current study, the reader must understand MA as it is described in contemporary education and psychology studies. Biological sex, international differences, MA measurement, and interventions are important contemporary issues to consider.

Biological sex. Researchers often blame the seemingly unfair distribution of MA in females versus males for the "low visibility of women in the science and engineering workforce" (Rubinsten, Bialik, & Solar, 2012, p. 1). The source of this disparity has served as the basis for much contemporary research. One study tested the notion that the relationship between biological sex and MA is mediated by spatial processing ability (Maloney, Waechter, Risko, & Fugelsang, 2012). After reviewing MA literature, another group of researchers highlighted the importance of perceived gender roles and the parent-child transmission of these stereotypes on math attitudes, including MA (Gunderson, Ramirez, Levine, & Beilock, 2012). Further, Casad, Hale, and Wachs (2015) found that this parent-to-child transmission of MA and sex-stereotyping decreased student math performance significantly ($p < .001$). Gender differences in MA may also be the result of female students' reactions to the learning environment – a statistically significant effect not observed in their male counterparts (Taylor & Fraser, 2013). Math anxiety prevalence, MA structure, and math performance with respect to male and female differences are discussed here to help the reader understand why student biological sex is an important independent variable in the current study.

Math anxiety prevalence. When Dreger and Aiken (1957) isolated MA from anxiety in general, calling it "number anxiety" (p. 344), the results excluded any mention of whether males or females had higher MA levels. However, starting in the 1970s, using different instruments and diverse populations, researchers have found, and continue to find, the average MA levels for females to be higher than those of males. Using a 10-item MA scale, a subscale of the Fennema-Sherman Math Attitudes Scale, Betz (1978) surveyed university students in two math courses and one psychology course. With a total of 652 participants consisting of slightly more females than males, statistically significant differences in MA levels were found. Math anxiety levels were higher for females overall, and higher for females in two of the course groupings. Though females had higher MA levels in the remaining course group, the difference was not statistically significant. Hopko et al. (2003) executed a preexperimental screening of 814 undergraduate students to identify the most highly anxious students for a subsequent experiment. The mean Revised Math Anxiety Rating Scale score for female students in the prescreening was higher than that of males at a significance level of $p < .001$. Smail (2017) used probability methods to explore the relationships between various factors thought to contribute to MA. Her nonstatistical study suggested that in 468 university students, female students are more likely than male students to have MA, as measured using the Abbreviated Math Anxiety Scale.

One particular group of college students, those enrolled in nursing programs, have served as the source of extensive analysis with respect to MA levels. Predominantly female, nursing candidates are trained to care for ailing patients and are preparing to enter what is often called a "helping profession." Nevertheless, the number and variety of math-related tasks that must be performed throughout the course of care-giving (e.g., blood pressure readings, medication dosage, body mass index calculations) necessitate successful math performance that could be hindered by MA (Bull, 2009; McMullen, Jones, & Lea, 2012). Pozehl (1996) found that while math performance of nursing students was lower than that of non-nursing students, there were no significant differences in MA levels between the groups. Still, efforts to study and manage nursing student MA and improve nursing student computational skills persist (Mackie & Bruce, 2016; Roykenes, 2016; Sredl, 2006; Walsh, 2008). These endeavors are merited, as a literature review by Williams and Davis (2016) demonstrated that MA is one of several factors that influence the outcomes of nursing student drug calculations.

Math anxiety structure. Wilder (2012) contended that MA in females bears a unique make-up from that of males. In other words, the characteristics of male MA are not analogous to those of female MA. In fact, the sex-dependent variations are so consistently blatant that instrument validity and reliability studies sometimes include additional steps to detect any possibility that the instrument is unusable for either males or females. For example, Primi, Busdraghi, Tomasetto, Morsanyi, and Chiesi (2014) and Vahedi and Farrokhi (2011) completed additional analyses to ensure that the Abbreviated Math Anxiety Scale instrument was valid and reliable for assessing MA in both sexes.

Studies of this phenomenon have focused on one or multiple characteristics. Rubinsten et al. (2012) used implicit measures (i.e., not self-report instruments) to study the influence of MA during numerical processing. Employing response times as a measure of anxiousness, these authors found statistically significant differences in male and female MA that resulted from positive and negative affective priming. They concluded that females tend to like math less than males and feel negatively toward it. Additionally, they reported that environmental factors were more important in the relationship between MA and math success for females (Rubinsten et al., 2012). Another group of investigators explored sex differences in spatial processing ability and their effects on MA (Maloney et al., 2012). These researchers applied structural equation modeling to test the idea that the tendency for females to be less skillful in understanding and applying symbolic information mediates the association between MA and gender. Their statistically significant results from Canadian university students and a subsequent diverse sample of adults supported this mediation model.

Even gender stereotypes regarding mathematics differentially affect MA in males and females. In a diary study of German high schoolers, Bieg, Goetz, Wolter, and Hall (2015) found that when girls endorse the idea that math is a male domain, they tend to overestimate their own MA levels. This effect, statistically significant for females, was not seen in males. Male-female differences were also evident in a multiple regression analysis of biological sex and eight possible predictors of MA with a group of 159 university students. Haynes et al. (2004) concluded that the relationships between MA and its predictors differed for each sex. In males, general test anxiety and American College Test (ACT) math scores significantly predicted MA level. In females, perceived math ability, perception of teacher ability, ACT score, and general anxiety were significant MA predictors. A notable result of the study is that while the correlation between ACT score and MA for males was negative (higher scores were associated with lower MA levels), female ACT score was positively associated with MA (as ACT score increased, MA level increased; Haynes et al., 2004). From the studies described here, it is evident that differing MA influencers and the variations in associations between MA components, require that special attention be placed on the effects of biological sex in MA intervention and treatment studies.

Math performance. The impact of sex-related MA differences on math performance appears to change throughout adolescence. Math anxiety variation due to biological sex is magnified as students progress through high school. Hill et al. (2016) reported that secondary school student achievement is significantly and negatively correlated with MA, while primary school student data do not display this relationship. If MA is inversely associated with math performance, and females in secondary and postsecondary educational programs tend to have higher levels of anxiety, then it would not be surprising if high school and college-age males out-performed females on mathematic assessments. The purpose of this section is to discuss study findings that highlight math achievement differences in men and women in secondary and postsecondary educational settings.

A study of 305 high school German students, designed to elucidate the sex-specific effects of motivational factors on success, also found that males outperformed females on final math course grades and numerical intelligence assessment scores (Steinmayr, Wirthwein, & Schone, 2014). The statistically significant results of this structural equation model analysis indicate that motivational variables, such as math ability, self-concept and math test anxiety, explained the between-sex variation in performance measures. In another study, Turkish high schoolers also showed a statistically significant gender-related association with math performance (Akben-Selcuk, 2017). Akben-Selcuk used a portion of the Programme for International Student Assessment (PISA) data set that included 4,858 students and revealed that male proficiency in math was higher than that of females.

Men have also outperformed women at the collegiate level. In a study of gender-specific estimation of math performance, seven questions from the Educational Testing Services Scholastic Aptitude Test were used to evaluate mathematics ability (Bench, Lench, Liew, Miner, & Flores, 2015). About half of the 110 undergraduate participants were women whose average assessment score was below that of the male participants ($p < .05$). Incidentally, men tended to overestimate how high they would score (Bench et al., 2015). Although their scores did surpass those of their female counterparts, males tended to predict a higher level of achievement than they subsequently earned. In this study, female participants did not overestimate their resultant scores with any statistical significance.

It is also worth noting that when male and female students achieve at the same level, teachers tend to offer different explanations for the successes. Males are applauded for their ability, while females are given credit for their efforts (Espinoza, Areas da Luz Fontes, & Arms-chavez, 2014). Conversely, when males are not successful, a lack of effort is to blame, but for females, teachers attribute nonsuccess to lack of ability. There may be some truth behind this seemingly biased interpretation of student failure and achievement. Although Sohn (2010) reported that the overall U.S. gender gap in math success may be waning, his findings suggest that underperforming females in lower grades experience declining successes as they age, while higher performing girls often catch up with their male counterparts. Not only is there a disparity between the sexes, but also among females based on assessed ability (Sohn, 2010). While lower performing males may not ever achieve the successes of higher performing males, they do tend to surpass the achievement of lower performing females. Thus, the relationship between ability level and the ability to improve performance is unique for males and females.

A meta-analysis study of two large international data sets revealed some interesting news about math achievement in young high schoolers. Else-Quest, Hyde, and Linn (2010) studied 2003 Trends in International Mathematics and Science Study and the PISA data sets and found that the direction and magnitude of gender differences in math achievement vary from culture to culture. These variations tend to be related to gender equity in education and career options. Therefore, environmental and non-academic contributors to math achievement may have as much or more influence on math success as intellectual ability. Cheema and Galluzzo (2013) contended that "the gender gap disappears once important predictors of math achievement, such as math-specific self-efficacy and anxiety, are controlled for" (p. 98). These significant findings, the result of a multiple regression study of the United States portion of PISA data, suggest that an intervention that reduces MA may also help to close the historical achievement gap between the sexes.

Measuring math anxiety. Math anxiety is a multi-faceted construct, which contributes to the undeniable difficulty of fully understanding its make-up. However, an advantage to its inherent complexity is that MA can be measured in a variety of ways. In fact, researchers have designed, tested, and validated methodologies to quantify MA levels based on physiological indicators and psychometric self-report questionnaires. In some cases, associations between the physiological measures and psychometric measures have also been studied.

Physiological measurements. The human body physically responds to stress and anxiety (Kelly et al., 2015; Lyons & Beilock, 2012; Sparks, 2011). Capitalizing on these physiological reactions and attempting to isolate and measure relevant markers, MA researchers have studied the ability of physiological measures to accurately assess MA presence and intensity. Their results have been inconclusive. Pletzer, Wood, Moeller, Nuerk, and Kerschbaum (2012) and Matterella-Micke, Mateo, Kozak, Foster, and Beilock (2011) found that salivary cortisol levels changed when study participants were presented with statistics and math problems, respectively. Throughout both studies, the findings were statistically significant for some participant groups, but not all. Since the results varied based on other student characteristics, such as high and low working memory, cortisol levels are not considered a definitive and useful measure.

In a study of the effects of music on MA, Gan, Lim, and Hall (2015) measured heart rate and systolic and diastolic blood pressure of participants and compared the results to two self-report instruments. Though pre and posttest changes in anxiety levels were detected from the questionnaire results, these investigators reported no statistically significant differences in the physiological measures of the different music exposure groups. Gan et al. (2015) attributed the failure of blood pressure and heart rate to reflect anxiety level changes as quickly as the self-report instruments to the fact that participant perception of anxiety precedes physiological response. The study may have found different results had the physiological measurements been taken at several points throughout the music intervention.

Psychometric instruments. While physiological measurements show little promise for quantitative comparisons between and among study participants, self-report MA instruments have a much longer and more substantial record. This includes a history of persistent attempts to revise MA questionnaires to better fit specific populations and improve implementation hurdles (Suarez-Pellicioni et al., 2016). For example, the original MA assessment instrument from Richardson and Suinn (1972), the Math Anxiety Rating Scale (MARS), contains 98 Likert-scale items. From the MARS instrument, Plake and Parker (1982) put forth the MARS-Revised that included only 24 items; Suinn and Edwards (1982) specifically revised MARS for adolescents; Suinn, Taylor, and Edwards (1988) created a version of MARS for elementary school students; and Alexander and Martray (1989) developed the sMARS or shortened MARS, which utilized 25 items. The latest instrument to be developed in this line of assessment tools is the Modified Abbreviated Math Anxiety Scale (Carey, Hill, Devine, & Szucs, 2017), a child-friendly version of the Abbreviated Math Anxiety Scale (Hopko, Mahadevan, Bare, & Hunt, 2003), which includes a mere nine questions.

All these instruments varied in ease of distribution and validity measures, justifying the need for a separate cohort of instruments. Independent of MARS, Betz (1978) created the 10-item Math Anxiety Scale (MAS). The MAS is a derivative of the Fennema-Sherman Math Attitude Scale, an instrument designed to assess attitudes toward math (as cited in Bai et al., 2009). Though MAS was shown to be internally consistent (Pajares & Urdan, 1996), it also had issues with construct validity (Bai et al., 2009). Therefore, Bai et al., in an attempt to correct these issues, created the 14-item Math Anxiety Scale – Revised (MAS-R), and subsequently reported “high internal consistency reliability, parallel-item consistency, and construct validity” (p. 190).

As described in the previous section, physiological measures have provided varied and unreliable results (Gan et al., 2015; Matterella-Micke et al., 2011; Pletzer et al., 2012). However, psychometric self-assessment MA instruments, such as the MAS-R, have consistently provided MA scores that can be compared statistically to determine the presence of significant effects resulting from an intervention. The MAS-R is the instrument chosen to evaluate student MA in the current study.

Interventions. A determination to find effective treatments and interventions began shortly after the conceptualization of MA. In search of potential best practices to alleviate the condition, Richardson (1980) studied the effects of rational-emotive therapy (RET) and problem-solving and relaxation technique training on MA levels. Although a reduction in MA means resulted for the RET group, there were no statistically significant MA reductions for either treatment group. Bander (1979) also investigated prospective MA treatments and detected differences in their efficacy, though results were not statistically significant. Out of several possible treatments, including study skills training, cue-controlled relaxation, subconscious reconditioning, and a combination of skills training and relaxation, study skills training affected decreases in MA and increases in math performance for all ability groups and both genders more than any other treatment tested.

While the Richardson (1980) and Bander (1979) findings are presented to show the long history of MA intervention studies, the next few examples illustrate contemporary attempts to find the most efficient and effective ways to reduce student MA levels. Loosely categorized into two types, instructional practice-based and student-centered intervention studies are discussed. An instructional practice-based MA intervention suggests purposeful manipulations of teaching methodology or curriculum design. The more student-centered interventions concentrate efforts on individualized needs, such as anxiety-reduction techniques, self-awareness exercises, and personalized curricula.

Instructional practice-based interventions. The focus of this type of intervention is on adjusting the learning environment so that students may experience less anxiety when learning math concepts or performing calculations. Macpherson (2016) endorses modification of instructional practice in his research-based plea for philosophy instructors to incorporate instructional strategies for student MA reduction. Based on previous studies, Macpherson touted the importance of cooperative learning strategies, self-paced modular learning, and mastery-goal teaching methodology. Cooperative learning was tested as an alleviator of MA in a quasi-experimental study of university statistics course students (Harding, 2015). Several introductory statistics class sections were redesigned to employ cooperative learning techniques, while traditional teaching methodology classes served as the control. Harding's findings indicated that females significantly benefited from cooperative learning, as evidenced by lower MA scores than their traditional instruction counterparts. Males did not experience these effects with any statistical significance.

Orabuchi (2013) incorporated the use of online visual interactive teaching technology into middle school math classes to determine whether this supplemental instructional strategy affects MA, math attitudes, and math performance. The three-month investigation yielded no significant math attitude and math performance differences between treatment and control groups. However, MA was improved in the treatment group, as shown by statistically significant increases in the positive subscale of the Math Anxiety Scale – Revised (Orabuchi, 2013). As a result, the author encourages the use of digital teaching technologies not as a replacement for but rather as a supplement to traditional teaching methods.

In another study, a mixed methods analysis of service learning's effects on MA, provided little evidence that service learning is an effective MA-reducing instructional strategy (Connor, 2008). Service learning is a pedagogical methodology that combines community service with academic coursework (Cashman & Seifer, 2008). However, the investigator reported that when teaching candidate preinterns complete a math methods course, mean MA levels are significantly lowered. While these results, elucidated from the Math Anxiety Rating Scale of Adults and qualitative analysis of student journal entries, do not support the use of service learning, they do suggest that supplementary coursework in math may help reduce MA. This notion is supported by findings from Sloan (2010) in her pre and postanxiety assessment of the preservice teachers who took a standards-based mathematics methods course. The author reported a statistically significant improvement in MA and suggested teacher candidates be screened and treated for MA before working professionally in the education field.

Student-centered interventions. When student characteristics (e.g., math self-efficacy, study strategies, anxiety) are the targets for change, a MA intervention can be considered student-centered. For example, Alcindor (2015) designed an intervention that included six 60-minute workshops for future elementary and special education teachers enrolled in a university education program. Sessions included instruction in problem-solving techniques, relaxation and MA management strategies, and math self-efficacy awareness. The results indicated no statistically significant differences in treatment and control group MA levels, diluting the argument for student-centered treatments.

However, other studies show promise for student-centric initiatives. Verkijika and Wet (2015) introduced brain-computer interface (BCI) technology as a methodology for managing and reducing student MA. As each middle or high school study participant completed computer-based math educational games, the BCI device, using brain activity readings, provided feedback on current MA level. Subsequently, at each MA reading, the student was also given advice on how to manage and reduce MA for the next math task. Participants experienced only two BCI sessions, presumably less than two hours each, yet statistically significant decreases in participant MA led the authors to state that “math anxiety can be effectively trained and reduced with a BCI” (Verkijika & Wet, 2015, p. 113).

In another student-focused intervention study, a group of researchers studied the effects of visual pet stimuli on MA. Torres, Arnold, and Shutt (2013) incorporated images of pets with various math problems. They also presented math problems that had pictures of items or graphics that were not related to pets. The investigators analyzed study participant self-reports of stress experienced with each type of math problem (pet or non-pet). The participants, recruited from university introductory psychology classes, reported lower levels of stress with math problems that were accompanied by pictures of pets. Although MA was not assessed using a validated MA instrument, the authors contend that the positive feelings resulting from seeing comforting visuals can reduce MA.

The two studies previously presented not only demonstrate student-centered interventions, but also suggest that successful initiatives need not be lengthy or invasive. Stogsdill's (2013) observations of his college math course students, and their reactions to his self-developed math therapy exercises, also support this notion. On the first day of each math course, or within the first module in online courses, Stogsdill poses six different topics upon which students must expound, including their earliest, best, and worst experiences with math. Though the author collects and reports no quantitative data, he cites anecdotal evidence from students regarding the helpfulness of the exercises. Stogsdill (2013) reports that the exercises, which can be completed in the first class meeting, help "students to move beyond the paralyzing grip of math anxiety and cultivate a more positive relationship with mathematics" (p. 121).

Let's Go Racing

As a mastery learning-based program, Let's Go Racing (LGR) incorporates both instructional practice and student-centered components. To justify the notion that LGR may reduce college student math anxiety (MA) levels, it is necessary to explain how the program applies mastery learning theory (MLT) concepts. The principal components of MLT curricula that e-learning course designers must include are:

- "formalization of cognitive outcomes,
- dividing content into units or modules,
- formative evaluations,
- feedback to correct instruction, and
- summative evaluation" (Grincewicz, 2015, p. 172).

Let's Go Racing, created by community college math faculty to help students become cognitively prepared to start their gateway math courses (Myers et al., 2016), adheres to the MLT framework. The LGR components corresponding to MLT elements are described in Table 2.1.

Table 2.1

Comparison of Mastery Learning Theory Elements and Let's Go Racing Components

MLT Element	LGR Component
1. Formalized cognitive outcomes	General statement of LGR goal (Readiness for Math 171); Pit Stop-specific objectives (e.g. Evaluate square roots of numbers.)
2. Content divided into units	Six skill-specific Pit Stops (e.g. Graphs and Equations with Lines)
3. Formative evaluation	Start Your Engines skill assessment quiz
4. Feedback to correct instruction	Pit Stop review sheets, lessons, and practice
5. Summative evaluation	Winners' Circle final assessment

Perhaps even more convincing of LGR's mastery learning roots is the original impetus for its creation. In 2014, the North Carolina Community College System implemented the

Multiple Measures of Placement Policy (Multiple Measures). Community colleges throughout the state were then required to comply with the new incoming student math and English course placement policy within the following two years (State Board, 2016). The new policy permitted a waiver of math and English course placement testing for incoming students who had graduated from high school within the previous five years with an overall 2.6 or above high school grade point average (Myers et al., 2015).

After Multiple Measures implementation, higher education professionals across the state community college system were concerned about the college-level readiness of incoming college freshmen with high school grade point averages between 2.6 and 3.0. As a participant in a multi-year research study involving student support program implementation to support these students, a small rural community college developed the LGR preparatory modules for gateway math and English courses (Clery, Munn, & Howard, 2017). Let's Go Racing developers designed a program that would help ensure that students master prerequisite skills before engaging in new, higher-level math concepts. The current study is specifically concerned with the Math 171 – Precalculus Algebra version of LGR and its ability to decrease MA. These modules have already shown promise for increasing student success in Math 171 (Myers et al., 2016). This study will examine whether they have any effect on MA.

Mastery Learning – Reciprocal Theory – Let's Go Racing Connection

Mastery learning theory-inspired programs continue to improve student learning and success (Barsuk, Cohen, Wayne, Siddal & McGaghie, 2016; Huang, Su, & Lee, 2017; Pardos, Whyte, & Kao, 2016; Rae & Samuels, 2011). Most relevant to the current study are MLT-based programs designed to boost student skills in preparation for college courses. Fiel and Okey (1975) found that invoking MLT principles to help students master prerequisite skills was significantly more effective than the provision of concurrent remedial practice. Hesser and

Gregory (2016), who incorporated components of mastery learning into embedded instructional support sessions, helped introductory-level chemistry students weak in math to enjoy the same course outcomes as students who tested at or above college-level in math. These results are not surprising, as Boylan, Bonham, Claxton, and Bliss (as cited in Boylan, 1999) found that individualized instructional strategies are associated with increased course completion, academic performance, and retention for remedial course students.

Considering the reciprocal theory notion that student success and math anxiety (MA) influence each other, it is reasonable to suspect that a mastery learning-inspired intervention, which has brought about improvements in student success, may also foster decreases in MA levels. Figure 2.3 depicts the components of the general diagram presented previously (see Figure 2.2), as they specifically apply to the current study. It also serves as a visual representation of what is known about the MLT-Student Performance-MA correlation. The current study will focus on the difference between MA levels for students who have versus those who have not completed the LGR modules.

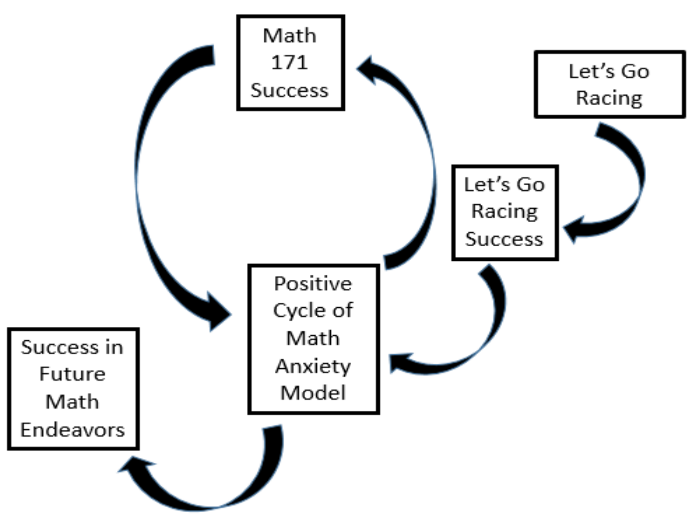

Figure 2.3. A model of the expected influence of Let's Go Racing intervention on community college student math anxiety and future math success.

Summary

The potential for a mastery learning-based intervention to help reduce math anxiety (MA) in community college students has been demonstrated in this chapter. Let’s Go Racing is a successful program, with respect to its contribution to gateway math course student success (Myers et al., 2016). Its potential to alleviate MA is likely to have more consequences than simple physiological and psychological relief. Let’s Go Racing may also contribute to improved math attitudes, math self-efficacy, future math courses, and career choices that otherwise would have been sidestepped. While this study aims to determine the effect of LGR on male and female students at a rural North Carolina community college, knowledge of the results may benefit higher education students, faculty, and administrators at universities and colleges throughout the United States.

CHAPTER THREE: METHODS

Overview

Let's Go Racing (LGR), an intervention that includes online modules designed to assess, prepare, and re-assess students in the prerequisite skills necessary to begin study in college-level pre-calculus algebra, has been shown to have a positive effect on student course success (Myers et al., 2016). While the inverse relationship between math anxiety (MA) levels and math course success (Clute, 1984; Hembree, 1990) may be due to various intermediate factors, Strawderman's (n.d.) math anxiety model suggests that improvements in math success are related to student progression along the model's Achievement continuum. Additionally, reciprocal theory (Carey et al., 2015) implies that increases in student math performance can help lower MA and that decreases in MA can bolster student success. The purpose of this study is to determine whether Let's Go Racing has an effect on the MA levels of community college students and whether those effects differ based on student biological sex. Chapter Three will include a discussion of the study's design, research questions and hypotheses, participants and setting, procedures, and data analysis.

Design

In order to investigate whether Let's Go Racing (LGR) has a significant impact on math anxiety (MA), a two-factor quasi-experimental posttest-only control group design was employed. This study cannot be considered truly experimental, because the assignment of participants into treatment and control groups was not random (Gall, Gall, & Borg, 2007). Rather, a convenience sample of pre-existing Math 171 course sections was divided at the institution level into two groups – a treatment group that participated in LGR prior to completing a MA evaluation instrument and a control group that only completed the MA assessment instrument. Quasi-experimental designs are inherently unable to ensure equality of participant groups, and thus weaken the internal validity of the study (Warner, 2013). However, they are often used in quantitative educational research. An advantage of quasi-experimental studies is that when using a convenience sampling of schools, classes, or class sections, the study's external validity can be improved. Therefore, the research tends to mimic actual educational settings (Warner, 2013).

The decision to forgo a pretest inclusive design stemmed from the intention to avoid error due to test sensitization. Warner (2013) described test sensitization as one of several possible issues with repeated measures. The administration of self-report instruments that assess personality or attitude prior to an intervention has been shown to have an effect on posttest administration outcomes of the same instrument (Gall et al., 2007). To avoid pretest sensitization issues and their potential effect on ecological validity, only one administration of the instrument took place for both treatment and control groups. It is important to note that without a pretest, the study design does not permit the ability to control for preexisting levels of MA in study participants. However, the inclusion of biological sex as an independent variable helped account for male and female differences.

A 2 x 2 factorial design indicates that two independent, nominal variables are under investigation. In the current study, one independent variable is participation status in LGR. The treatment group participated in LGR, while the control group did not. The second independent variable is the biological sex of the student. Math anxiety manifests itself differently in males and females (Haynes et al., 2004; Wilder, 2012). In addition, although not an issue found in primary and middle school students, the prevalence of MA is generally higher in females than it is in males in secondary and postsecondary educational settings (Betz, 1978). Investigating the influence of biological sex and LGR participation on MA and the potential interaction between these variables provided information about whether LGR helps reduce MA and if that effect differs for male and female community college students.

Research Questions

This study explored three research questions:

RQ1: Is there a difference between the mean math anxiety scores of community college students based on online math module participation?

RQ2: Is there a difference between the mean math anxiety scores of community college students based on biological sex?

RQ3: Is there an interaction effect between online math module participation and biological sex on the mean math anxiety scores of community college students?

Hypotheses

The following three null hypotheses were tested in this study:

$H_0$1: There is no statistically significant difference between the mean math anxiety scores of community college students who complete an online math intervention and the mean math anxiety scores of students who do not complete an online math intervention.

$H_0$2: There is no statistically significant difference between the mean math anxiety scores of male and female community college students.

$H_0$3: There is no significant interaction between online math intervention participation and biological sex with regard to the mean math anxiety scores of community college students.

Participants and Setting

The participants for this study were male and female Math 171 – Pre-calculus Algebra students at small-to-medium-sized North Carolina community colleges. The treatment group was selected from an institution that already utilized the Let's Go Racing online math intervention. It is located in a rural setting and has one campus and two satellite education centers. Actual demographic data of the treatment and control groups will be reported in Chapter

Four, but the most recently available biological sex, age, and ethnicity data of the treatment site were used as a reference point to select a demographically similar control group site.

The treatment group Fall 2015 student body was 70% female and 30% male. The age group percentages of all Fall 2015 students were 54% ages 24 and under and 46% ages 25 and over. Student-reported ethnicities for the same term were 70% White, 15% Black or African American, 3% Asian, 2% Hispanic, and 8% other, unknown, or multi-racial ("U.S. Department of Education," 2017). The institution's main campus houses an early college, a special program that allows an enrolling ninth grader to achieve a high school diploma and an associate degree within five years ("Early College," 2017). Additionally, the institution participates in the Career and College Promise Program, which allows students in traditional high schools and home school programs to take college classes ("Career and College Promise," 2017).

The control group included Math 171 students from a community college that is also located in North Carolina. This institution has only one campus. The Fall 2015 Curriculum student body was 64% female and 36% male. The age group percentages of all Fall 2015 students were 64% ages 24 and under and 36% ages 25 and over. Student-reported ethnicities for the same term were 73% White, 18% Black or African American, 4% Hispanic, 1% Asian, and 4% other, unknown, or multi-racial ("U.S. Department of Education," 2017). This college also offers an early college option and the Career and College Promise Program.

At the treatment group site, Math 171 classes are either 16 or 12 weeks in duration, beginning in early January or early February, respectively, and ending in early May of the Spring 2018 term. At the control site, Math 171 course sections begin in early or mid-January and end in early May. Though it was intended that all relevant project components be completed in an online format during the first eight calendar days of each class, the method of MA assessment instrument delivery and parental consent form submission varied. Students were free to choose their own locations for the completion of electronically-delivered activities. Therefore, the setting for instrument completion was in a home, library, on-campus computer lab, or other site that had Internet connectivity. In two of the treatment group sections, the instrument was delivered in the classroom via school laptop computers. For four sections at the control group site, students completed the assessment on paper. These responses were then entered into the electronic survey system via its manual entry option.

Parental consent for students ages 17 and under was achieved in various ways, based on the student's Math 171 class method of delivery and the student's postsecondary school situation. Underaged control site students, where all class sections included a seated component, were given a parental permission form the first week of class (Appendix B). Completed forms were collected at a subsequent class meeting prior to MA assessment. The same procedure was used with underaged treatment site students in class sections with a seated component. For students 17 and under in treatment site online-only sections, home school students were mailed the form, students in area high schools received the form from the college's high school liaison, and early college students received the form from the early college high school counselor. Completed forms were collected by the course teacher, liaison, or counselor and then submitted for study review and secure storage.

The sample in this study met the participant requirement for a medium effect size (Gall et al., 2007). For a 2 x 2 factorial study with a statistical power of .5 at the .05 alpha level, 96 participants are needed (p. 145). Course sections have an average enrollment of 20 students, resulting in a possible total of 200 (20 x 10) study participants. A total of 103 students completed the study, including 42 males and 61 females. Study participant age group percentages were 17.5% 17 or younger, 57.3% 18 to 20, 12.6% 21 to 29, 4.9% 30 to 39, 4.9% 40 to 49, 1.0% 50 to 59, and 1.9% 60 or older. Self-reported ethnicity percentages were 73.8%

White, 7.8% Black, 6.8% Asian, 2.9% Hispanic, and 8.7% Multi-racial, Unknown, or not reported.

Math 171 is one of three North Carolina Community College gateway math courses. A gateway course is the first college credit course in math or English for students pursuing an associate degree, diploma, or certificate. All North Carolina community college students in college credit programs must enroll in Math 171 or one of two alternatives. Students who enroll in Math 171 are typically in university transfer programs, having plans to transfer as junior transfer students to a four-year institution ("Comprehensive Articulation Agreement," 2014). Learning objectives for the Math 171 course include analyzing functions and solving algebraic equations and inequalities. The primary goal of the course is to establish all algebraic skills needed to be able to study Calculus in subsequent coursework (North Carolina Community College System, 2016).

Instrumentation

The Math Anxiety Scale – Revised (MAS-R) was administered to assess the math anxiety (MA) levels of study participants. Bai et al. (2009) report high psychometric properties for MAS-R from a validation study in a midwestern community college. Consistency and parallel-item reliabilities were found to have Cronbach α coefficients of .91 and .87, respectively. Factor loadings between .67 and .89 suggest high construct validity (Bai et al., 2009). The MAS-R, written on a fourth-grade reading level, was also studied in alternate populations to determine validity and reliability in various settings. Good psychometric quality of the instrument was found when used with seventh- and eighth-grade prealgebra and algebra students (Bai, 2011). In a study of ninth-grade Iranian male students, the MAS-R was also found to be valid and reliable enough to "be used in clinical and investigational applications" (Nayeri, Varzaneh, & Raoof, 2014, p. 136).

MAS-R, a modified version of Betz's (1978) Math Anxiety Scale, is a 14-item self-report questionnaire with five-point Likert scale response options ranging from Very True to Not True. Since MAS-R is a bidimensional scale, designed to identify both positive and negative feelings toward mathematics, seven of the items require reverse scoring. Responses for negative items are scored as Very True = 5, Mostly True = 4, Moderately True = 3, Slightly True = 2, and Not True = 1, and positive item responses are scored in reverse order. With a total score range of 14 to 70, higher scores indicate high math anxiety. Permission to use the MAS-R in the current study has been granted (Appendix C).

Demographic items were added to the MAS-R instrument, so that biological sex, age group, and ethnicity of the current study participants could be ascertained. A question regarding LGR completion status was also included for the treatment group MAS-R to ensure that treatment group participants have participated in LGR prior to the MAS-R completion. These additional questions and the MAS-R survey items were manually entered into a commercial online survey software tool. Dr. Haiyan Bai, leader of the team that created and validated the MAS-R instrument, reviewed the electronic version for completeness and accuracy.

All or part of the MAS-R has been used in recent studies of MA and related conditions. Adams (2012) used the full MAS-R in a mixed-methods study of anxiety in elementary students, teachers, and preservice teachers. In a study of non-math majors' beliefs about math and their effects on success in college math courses, researchers included three items from the MAS-R in their 32-item Math Belief Scale (Daugherty, Rusinko, & Griggs, 2013). Combining questions from several instruments, Alvez, Rodrigues, Rocha, and Coutinho (2013) incorporated five MAS-R items into a questionnaire to explore math application ability in Portuguese engineering students. Not only is MAS-R valid and reliable, but its popularity and practicality in educational settings renders it a fitting choice for the current study.

Procedures

The Liberty University (LU) Institutional Review Board (IRB) has approved this study (See Appendix D). Prior to LU IRB approval, two rural North Carolina community colleges granted consent for their students to participate. Approval letters from the treatment and control site are provided in Appendices E and F, respectively.

Let's Go Racing (LGR) has been implemented consistently at the research site since the Fall 2015 semester. The program is delivered to students via Pearson's MyLab Math, a learning management system unique to schools utilizing Pearson materials. For the treatment group and control group, parental consent was required for students who were less than 18 years old. Both institutions house an early college and offer the Career and College Promise Program. Therefore, some Math 171 students fell into this age group. Parental permission was achieved via a hard copy parental consent form (Appendix B) disseminated prior to or on the first day of class.

Since the proposed treatment group study site already incorporates LGR into Math 171 coursework, the logistics of the current math anxiety (MA) study were in place with few revisions needed. Treatment group course instructors initiated the distribution of two items in addition to the already-established LGR modules. Dissemination of the consent form for study participation (Appendix G) and the Math Anxiety Scale – Revised (MAS-R; Bai et al., 2009) with demographic questions followed LGR completion on or about the eighth calendar day after the beginning of each Math 171 course. Instructors at the control group site distributed an electronic link to the study consent form and MAS-R to the control group on or about the eighth calendar day after the start of the Math 171 course sections. Electronic completion of the MAS-R was minimal, obliging the control site to distribute the instrument in hard copy form. As a result, four sections of the control site participants completed the MAS-R assessment on paper.

Students in these sections were asked to not complete the hard copy version of the assessment, if they had already completed the electronic version.

When the MAS-R instrument and consent form were disseminated to students in online course sections, instructors used the email message template shown in Appendix H. To ensure that treatment group students actually completed the LGR intervention prior to MAS-R participation, a question was added to the treatment group instrument allowing students to self-report whether LGR had been completed. Responses from the one treatment group student who indicated that LGR was not completed prior to the MA assessment, were removed from the data set.

Math 171 faculty were directly involved in the delivery of LGR (if applicable), the study consent form, and the MAS-R. To help guarantee that instructors completed this process in accordance with study design, a two-part faculty training strategy was employed. First, instructional materials that highlight the study's purpose and intent and detail the steps for ensuring proper delivery of the study materials (see Appendix I) were provided to instructors. Since the completion of the consent form and MAS-R must be entirely voluntary in accordance with standard IRB procedure, the importance of not incentivizing student completion of MAS-R by associating it with a course grade was stressed to math course instructors. The second tier of the training, following training material dissemination, involved researcher contact with instructors (at the treatment site) and the Math Department Chair (at the control site). This call, email, and in-person correspondence gave faculty an opportunity to gain clarification on any issues regarding the study.

Participants for the study were recruited from preexisting Math 171 course sections. With the assistance of the Mathematics Department Head at the treatment study site, students from all Spring 2018 Math 171 sections were offered the opportunity to participate in the study.

The Math Department Chair at the control group study site communicated with control group participants. It was imperative that students complete the MAS-R at comparable times in their Math 171 course sections so that extraneous factors, such as time in the Math 171 course, did not pose threats to internal validity. Let's Go Racing treatment was completed during the first eight days of class. The MAS-R was then made available to students between Day 8 and Day 42. Participant completion of the intervention (when applicable) and MA assessment occurred within a 42-day period.

All MAS-R responses were collected via an electronic survey system link or by administering a paper copy to potential participants. When paper surveys were used, participant responses were entered into the electronic link, so that all responses were eventually recorded using the electronic survey system. A computer lab with Internet access was provided for students who did not have access to the Internet or who prefer to complete the work on campus. However, initially low response rates at the control site prompted the need to distribute the survey in hard copy form. When hard copies were distributed, students were reminded that participation was voluntary. Additionally, students were instructed to avoid completing the hard copy survey if they had already completed the survey in electronic form. Although the same assessment instrument with supplemental questions was administered to all participants, two different survey links, one for the treatment group and one for the control group, allowed group-specific data collection. The instruments included a question regarding biological sex so that this independent variable could also be examined.

All information was stored on the survey software company's server, which is only accessible by a unique username and password. Data were transferred to statistical analysis software application via a SAV file export and upload. Since manual entry of the paper copy responses was required, it was necessary to review these entries to certify accuracy. Twenty-five percent of the 48 paper copy responses were compared to the entries made in the electronic survey link. All 12 of the reviewed entries, which were randomly selected, were accurately entered.

To certify accuracy of data transfer from the electronic survey system to the statistical analysis software, a manual review of 10% of each of the control and treatment cases was completed. The statistical analysis software uploads for these cases were reviewed to ensure that they matched the responses collected via the survey software. In addition, all data were reviewed to ensure that values are within variable-specific limits. For example, total MAS-R score must be between 14 and 70, inclusive. Throughout data analysis, survey results were stored on a personal laptop computer that was password-protected.

Data Analysis

Two-way analysis of variance (ANOVA) was employed to test the experimental hypotheses. However, before ANOVA statistics were computed, descriptive statistics and assumption testing regarding the study sample was completed.

The following assumptions are fundamental to the data in two-way ANOVA analyses (Warner, 2013):

- Normal distribution of dependent variable scores (MA level as determined by MAS-R in this study),
- Dependent variable scores result from independent observations (one student’s MAS-R score is not influenced by another student’s score), and
- Homogeneity of score variance among groups of independent variable values (for example, male LGR participants versus female non-treatment participants).

Normal distribution of MAS-R scores was examined by observing a histogram of total MAS-R scores. A Kolmogorov-Smirnov test was also executed, since this is the conventional test of normality when total participant count is greater than 50 (Rockinson-Szapkiw, 2013). Results for a one-sample chi-square test were also computed for total MAS-R score. Regarding independent observation, MAS-R scores (observations) are by study design, independent of one another. Students completed the MAS-R independently. Finally, Levene's test of homogeneity of variance was employed to determine if the assumption of equal variances was tenable (Warner, 2013).

Three null hypotheses were tested in this study. The first, $H_0 1$, required examination of the mean levels of MA (dependent variable) in two groups of students – one whose members participated in the Let's Go Racing online math intervention, and the other whose members did not (independent variable). The effect of a second independent variable, biological sex, on MA scores was examined in $H_0 2$. The third null hypothesis required a test for an interaction effect between the two independent variables, LGR participation and biological sex. Therefore, a two-factor posttest-only control group design was used in this study.

All three null hypotheses were tested using two-way ANOVA procedures, as this is one of three possible methodologies to analyze two-factor experimental designs (Gall et al., 2007). The need to determine independent variable main effects and interaction effect can be met using two-way ANOVA (Green & Salkind, 2014). Analysis of covariance, a second option for two-factor experimental design analysis is used when the experimenter is controlling for certain variables, such as baseline level of math anxiety. While Gall et al. (2007) suggest using a pretest of the dependent variable along with analysis of covariance in order to control for pre-existing levels of MA, the risk of test sensitization to the MAS-R necessitated the omission of a pretest in this study. Therefore, no MAS-R preassessment was administered. Multiple regression is also an acceptable method to analyze the results from two-factor experiments, but it is recommended "for reducing a large number of variables to a small number of factors" (Gall et al., 2007, p.

354). The current study is focused on three variables – biological sex, LGR participation, and math anxiety. Two-way ANOVA is sufficient to determine the presence or absence of statistical significance in the resultant group mean differences (Green & Salkind, 2014).

Green and Salkind (2014) reported that the effect size computed for a two-way ANOVA is a partial eta squared (η^2). Ranging in value from zero to one, partial η^2 describes the variance in scores based on one of the independent variables, while excluding the variance attributed to the remaining independent variable. A partial η^2 is also computed for the interaction of the independent variables, excluding the influence of the independent variables acting alone. Warner (2013) stated that "partial η^2 values are typically larger than simple η^2 values" (p. 520). Green and Salkind (2014) reported that cut-offs for small, medium, and large effect sizes measured in η^2 are not equal to those for partial η^2 values. Therefore, conventions from MA studies helped to determine that a medium effect size was appropriate for this study.

Relevant assumption tests were completed, and descriptive statistics were computed. All three null hypotheses were tested using an analysis of variance via *F* ratio calculation. Additionally, the results of the *F* ratio calculations were used to make statistical decisions of whether to reject or fail to reject the study hypotheses.

CHAPTER FOUR: FINDINGS

Overview

This chapter describes the sample groups, data collected and statistical analyses of the data with respect to the study research questions and null hypotheses. Treatment and control group demographic data, descriptive statistics, assumption tests and analysis of variance (ANOVA) results are provided. Decisions regarding the null hypotheses are also presented.

Research Questions

This study focused on three research questions. They are listed here:

RQ1: Is there a difference between the mean math anxiety scores of community college students based on online math module participation?

RQ2: Is there a difference between the mean math anxiety scores of community college students based on biological sex?

RQ3: Is there an interaction effect between online math module participation and biological sex on the mean math anxiety scores of community college students?

Null Hypotheses

The corresponding hypothesis for each research question was tested. The null hypotheses are listed here:

$H_0$1: There is no statistically significant difference between the mean math anxiety scores of community college students who complete an online math intervention and the mean math anxiety scores of students who do not complete an online math intervention.

$H_0$2: There is no statistically significant difference between the mean math anxiety scores of male and female community college students.

$H_0$3: There is no statistically significant interaction between online math module participation and biological sex with regard to the mean math anxiety scores of community college students.

Descriptive Statistics

All Spring 2018 Math 171 – Precalculus Algebra (Math 171) students from two small-to-medium sized North Carolina community colleges were invited to participate in the study. Of the 79 treatment site students who were provided the Math Anxiety Scale – Revised (MAS-R) instrument, 45 agreed to participate. However, one respondent indicated non-completion of the intervention and three respondents did not answer a majority of the MAS-R items. Therefore, the final number of treatment site participants was 41. Of the 88 control site students who were offered the MAS-R instrument, 69 agreed to participate. The responses from five of these participants were removed from the study results as they were submitted prior to the start of the predetermined data collection date. The submissions of two additional responses were also removed due to non-response of several MAS-R items. The final number of control site participants was 62. Response rates for treatment and control groups were 52% and 70%, respectively.

Participant Characteristics

While demographics of the total sample are described in Chapter Three, the composition of the treatment and control groups based on participant biological sex, age group, and ethnicity are shown in Tables 4.1, 4.2, and 4.3, respectively. The final study sample (N = 103) included 42 males and 61 females, and each group consisted of more females than males. While the treatment group contained twice as many females as males, the control group was only 54.8% female. Very little variation was observed in age group composition between the two groups. With the exception of the control group having three participants ages 50 and over and the treatment group having no participants over 49, age groups differed 4.1 percentage points or less between groups. While both groups were predominantly White (65.9% and 79.0% in the treatment and control groups, respectively), some variation is noted in the remaining ethnicity categories. For example, the treatment group, which had one participant who chose not to report ethnicity, had slightly higher percentages of students selecting the Asian, multiple races, and other categories. Additionally, there were three Hispanic participants in the control group, but none in the treatment group.

Table 4.1

Biological Sex Composition of Treatment and Control Groups

	Treatment		Control		Total
	n	*%*	*n*	*%*	*n*
Males	14	34.1	28	45.2	42
Females	27	65.9	34	54.8	61
Total	41	100	62	100	103

Note. Percentages are reported as proportion of total in treatment or control group.

Table 4.2

Age Group Composition of Treatment and Control Groups

	Treatment		Control		Total
	n	%	*n*	%	*n*
17 and Under	7	17.1	11	17.7	18
18 to 20	24	58.5	35	56.5	59
21 – 29	5	12.2	8	12.9	13
30 – 39	3	7.3	2	3.2	5
40 – 49	2	4.9	3	4.8	5
50 – 59	0	0.0	1	1.6	1
60 and Older	0	0.0	2	3.2	2
Total	41	100	62	99.9	103

Note. Percentages are reported as proportion of total in treatment or control group.

Table 4.3

Ethnicity Composition of Treatment and Control Groups

	Treatment		Control		Total
	n	*%*	*n*	*%*	*n*
White	27	65.9	49	79.0	76
Black or African American	2	4.9	6	9.7	8
Asian	6	14.6	1	1.6	7
Hispanic	0	0.0	3	4.8	3
Multiple Races	3	7.3	2	3.2	5
Other	2	4.9	1	1.6	3
Not Reported	1	2.4	0	0.0	1
Total	41	100	62	99.9	103

Note. Percentages are reported as proportion of total in treatment or control group.

Dependent Variable

The dependent variable in this study was measured using the Math Anxiety Scale – Revised (MAS-R), a 14-item self-report questionnaire designed to identify positive and negative feelings toward mathematics (Bai et al., 2009). The development, validity, and reliability of the MAS-R instrument are detailed comprehensively in Chapter Three. With a total math anxiety (MA) score range of 14 to 70, lower scores indicate low levels of MA and higher scores indicate high levels of MA. The mean MAS-R scores for study participants are shown in Table 4.4.

Table 4.4

Descriptive Statistics for Total Math Anxiety Scores

	Treatment (*n* = 41)			Control (*n* = 62)			Total		
	n	*M*	*SD*	*n*	*M*	*SD*	*n/N*	*M*	*SD*
Males	14	36.71	9.43	28	34.57	12.07	42	35.29	11.19
Females	27	39.85	12.29	34	41.71	12.45	61	40.89	12.31
Total	41	38.78	11.38	62	38.48	12.70	103	38.60	12.13

Note. Total possible scores range from 14 to 70.

Results

After completing the data screening and verification measures described in Chapter Three and computing the descriptive statistics presented in the previous section, assumption testing required for two-way ANOVA analyses was completed. Subsequently, ANOVA results were analyzed in order to determine whether each of the study null hypotheses would be rejected or fail to be rejected.

Assumption Tests

A 2 x 2 factorial ANOVA analysis requires that the assumptions of normality and homogeneity of score variance be tested and verified (Gall et al., 2007). A histogram of total MAS-R scores for the sample suggested a normal distribution (Figure 4.1). The results of a Kolmogorov-Smirnov test (p = .164) supported this observation. Normality of the total MAS-R scores was also tested using a one-sample chi-square test. Results indicated this assumption to be tenable (p = .989). Levene’s test of equality of error variances was calculated to examine the data for homogeneity of variances. No violation of this assumption was found, $F(3, 99) = .396$, $p = .756$.

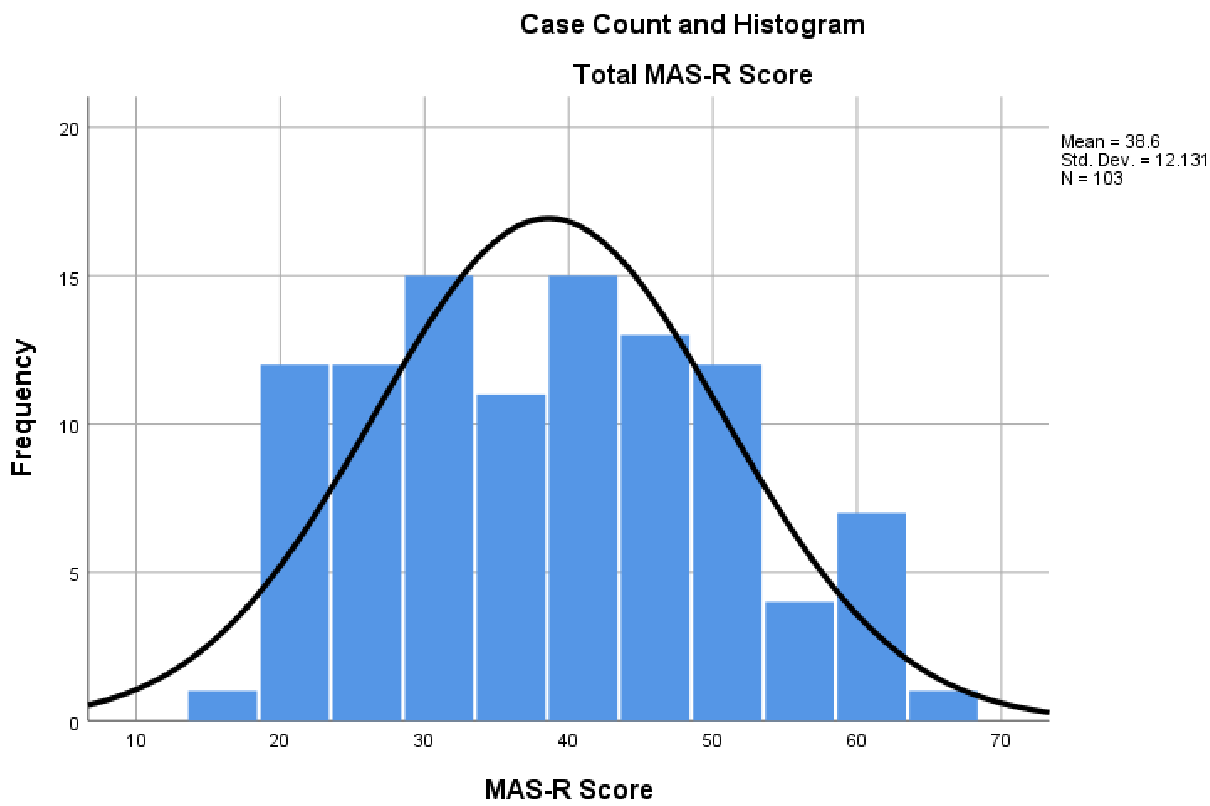

Figure 4.1. A histogram of total math anxiety scores of all study participants (*N* = 103) as measured by the Math Anxiety Scale – Revised.

Null Hypothesis One

The first null hypothesis examined in this study is "There is no statistically significant difference between the mean math anxiety scores of community college students who complete an online math intervention and the mean math anxiety scores of students who do not complete an online math intervention." The purpose of this hypothesis is to explore what effect one of the independent variables, participation status in the online math intervention, might have on the dependent variable, total math anxiety score. Mean scores for the treatment (*M* = 38.78) and control (*M* = 38.48) groups differed but not with statistical significance. As shown in Table 4.5, the ANOVA resulted in no significant main effect of intervention participation on total MAS-R score, $F(1, 99) = .003$, $p = .954$, partial $\eta^2 = .000$. As a result, this first null hypothesis failed to be rejected.

Table 4.5

Analysis of Variance Results for Null Hypothesis One

Treatment (n = 41)		Control (n = 62)				
M	*SD*	*M*	*SD*	*F* Ratio	*p*-value	Partial η^2
38.78	11.38	38.48	12.70	*F* = .003	.954	.000

Null Hypothesis Two

The second null hypothesis of this study, which states "There is no statistically significant difference between the mean math anxiety scores of male and female community college students" was tested in order to determine the effect of biological sex on math anxiety level. The math anxiety score mean for males (M = 35.29) was lower than that of females (M = 40.89). Analysis of variance for biological sex difference in the dependent variable of total MAS-R scores was significant, $F(1, 99) = 4.257$, $p < .05$, partial $\eta^2 = .041$, as shown in Table 4.6. As a result, the second null hypothesis was rejected.

Table 4.6

Analysis of Variance Results for Null Hypothesis Two

Male (n = 42)		Female (n = 61)				
M	*SD*	*M*	*SD*	*F* Ratio	*p*-value	Partial η^2
35.29	11.19	40.89	12.31	*F* = 4.257	.042	.041

Note. $p < .05$

Null Hypothesis Three

The third null hypothesis, "There is no significant interaction between online math module participation and biological sex with regard to the mean math anxiety scores of community college students," explores the interaction effect of the two independent variables, online math module participation and biological sex, on the dependent variable, total MAS-R score. Each independent variable has two levels, participation and non-participation in the online math modules intervention and male and female for biological sex. The dependent variable is continuous and ranges in value from 14 to 70.

Means for treatment group males and control group males were 36.71 and 34.57, respectively. Means for treatment group females and control group females were 39.85 and 41.71, respectively. As displayed in Table 4.7, the ANOVA analysis was not significant, $F(1, 99) = .644$, $p = .424$, partial $\eta^2 = .006$. This resulted in failure to reject the null hypothesis and indicates no interaction effect of the two independent variables in this study.

Table 4.7

Analysis of Variance Results for Null Hypothesis Three

	Treatment			Control					
	M	*SD*	*n*	*M*	*SD*	*n*	*F* Ratio	*p*-value	Partial η^2
Male	36.71	9.43	14	34.57	12.07	28	.644	.424	.006
Female	39.85	12.29	27	41.71	12.45	34			

Summary

In this chapter, descriptive and inferential statistics were presented along with information regarding the required assumption tests for two-way ANOVA analyses. The study sample included more females than males, and the control group comprised more participants than the treatment group. Total MAS-R scores were normally distributed throughout the sample and varied equally among groups.

In the current study, overall MA levels were not affected by the online math intervention with any statistical significance, leading to a failure to reject the first null hypothesis. Yet, analysis of the data in regard to the second research question reveal that biological sex appears to influence the levels of MA for these Math 171 students. This resulted in a rejection of the second null hypothesis. Analysis in regard to the third research question indicates MA score means were lower for females who participated in the online math intervention, when compared to females who did not participate in the intervention. However, MA scores were higher for males who participated in the intervention than they were for those who did not. Though a difference in group means surfaced from the analysis, interaction effect of the two independent variables was not significant. Therefore, the third null hypothesis failed to be rejected. Table 4.8 summarizes the determinations made after ANOVA testing of the three null hypotheses.

Table 4.8

Summary of ANOVA Results and Null Hypotheses Determinations

Null Hypothesis	Independent Variable	*p*-value	Reject Null
$H_0 1$	Math Module Participation	.954	No
$H_0 2$	Biological Sex	$< .05$	Yes
$H_0 3$	Interaction Math Intervention Participation*Biological Sex	.424	No

CHAPTER FIVE: CONCLUSIONS

Overview

The purpose of this chapter is to discuss the results from the current research study with respect to their contribution to the knowledge of math anxiety (MA) and MA interventions in postsecondary education students. Each of the research questions and null hypotheses are examined, and study limitations are reported. The implications of the results with respect to current literature and recommendations for future research are also examined.

Discussion

The purpose of this study was to test the effects of Let's Go Racing (LGR), a set of online preparatory math modules, on math anxiety levels in community college students. This study's two-factor quasi-experimental design also permitted the investigation of any differential effect LGR may have on males versus females. The Achievement continuum of Strawderman's (n.d.) model of math anxiety and the mutually influencing relationship between math anxiety (MA) and math performance posited by the reciprocal theory (Carey et al., 2015) suggest a need to investigate the effect of a set of online math modules, which have been shown to be associated with student success, on MA. Treatment and control groups were given the Bai et al. (2009) Math Anxiety Scale – Revised. The independent variables were the status of LGR module participation as part of a Math 171 – Precalculus Algebra course and biological sex. The dependent variable was the mean levels of MA for males and females in the treatment and non-treatment groups. In this study, three research questions were proposed, and three corresponding null hypotheses were tested.

Research Question and Null Hypothesis One

The first research question and accompanying null hypothesis focused on the independent variable of LGR participation. The research question "Is there a difference between the mean math anxiety scores of community college students based on online math module participation?" was posed as an attempt to explore the potential effects of an online mastery learning theory-based intervention on community college precalculus algebra student MA. The associated null hypothesis states "There is no statistically significant difference between the mean math anxiety scores of community college students who complete an online math intervention and the mean math anxiety scores of students who do not complete an online math intervention." Analysis of variance assessment revealed a small difference between treatment and control group MA score means that was not statistically significant. As shown in Table 4.5, the results of the ANOVA were $F(1, 99) = .003$, $p = .954$, partial $\eta^2 = .000$. Thus, the null hypothesis failed to be rejected.

A comprehensive review of the literature regarding MA, mastery learning theory (MLT) activities, and math performance suggests that a MLT-based intervention that has been linked to improved math performance and student success may also have an impact on MA level. Let's Go Racing, the set of online math modules utilized in the current study, is a mastery learning curriculum that is associated with improved student performance in community college gateway math courses (Myers et al., 2016). The inverse relationship between math performance and MA has been studied repeatedly in myriad age groups (Dutko, 2015; Nunez-Pena et al., 2013; Wu et al., 2012) and varied cultural settings (Kyttala & Bjorn, 2010; O'Leary, Fitzpatrick, & Hallett, 2017; Recbur, Isiksal, & Koc, 2018). Thus, an intervention that has a positive relationship with student success has the potential to have a negative relationship with MA level.

Let's Go Racing and similar treatments may not only have an inverse association with MA but may also effect a change in MA levels. This notion is upheld by both the Strawderman (n.d.) math anxiety model and the Carey et al. (2015) reciprocal theory. Both views highlight a cyclical relationship between MA and math performance. Reciprocal theory takes this a step further by implying that a change in either component causes a change in the remaining component. In other words, MA and math performance levels mutually influence each other (Carey et al., 2015). It is reasonable to suspect that an intervention that improves math success also lowers MA.

These ideas were not supported by the current study. In fact, the mean MA levels for the treatment group were slightly higher than those of the control group (see Table 4.5). With no significant difference in MA levels between treatment and control groups, neither a positive or negative impact of the intervention can be verified. Perhaps the length of the intervention is an issue with regards to impact on MA. Evidence from a previous study suggests these online math modules were extensive enough to have a positive impact on student success (Myers et al., 2015), despite their relative brevity. Similarly, a study of an online mastery learning curriculum with imposed time constraints for completion actually improved student learning and academic performance (Ee, Yeoh, Boo, & Boulter, 2018). This suggests that the succinctness of LGR would not be an issue with regard to its impact on student math performance.

However, LGR's brief completion time (10 hours or less) may have been an impediment to its ability to alleviate MA. While the MLT principles provided the assessment, feedback, practice, and re-assessment of skills necessary for success in college-level precalculus algebra, they could be devoid of the elements necessary to undo years of developing MA. This may be why many previously proposed MA interventions are more long-term endeavors, such as the modification of instructional practice (Macpherson, 2016), a three-month-long incorporation of online visual interactive instruction (Orabuchi, 2013), and the integration of cooperative learning techniques (Harding, 2015).

Intervention quantity would seem to be more important than quality were it not for the promising results of some less invasive MA-reducing treatments. Verkijika and Wet (2015) showed statistically significant reductions in middle and high school student math anxiety levels with only two 120-minute sessions of an exercise that included task completion, MA level feedback, and advice on how to manage and reduce MA. Though not quantitatively assessed, Stogdsill (2013) introduces an exercise within one college math class meeting that he claimed reduces student fears about learning math. Finally, the effects of brief guided imagery, in the form of a 20-minute session of listening to recordings that guide the participant to envision calming scenes, were studied in undergraduate students (Henslee & Klein, 2017). Control group participants were also required to spend 20 minutes of quiet rest but did not hear the guided imagery recordings. Though there was no difference in the MA reduction between treatment and control groups, both groups had statistically significant lower posttest than pretest MA scores.

The potential for short-term interventions to alleviate MA is credible. However, results from the test of this null hypothesis imply that Let's Go Racing does not lower math anxiety for a coed group of community college students. The interaction null hypothesis test results, to be discussed later, may shed light on the effect of the online modules with respect to each biological sex group.

Research Question and Null Hypothesis Two

To study the second research question, which pertains to differences in MA levels with respect to biological sex, the null hypothesis "There is no statistically significant difference between the mean MA scores of male and female community college students" was tested. The ANOVA analysis resulted in a statistically significant difference between the mean MA levels of all females and all males (see Table 4.6). The female MA average score was 5.6 points higher than the male average MA score, $F(1, 99) = 4.257$, $p < .05$, partial $\eta^2 = .041$. Therefore, this null hypothesis was rejected.

As previously discussed, the prevalence of MA in females is generally accepted as being higher than that of males. Though this is not true in every age group (Reali, Jiminez-Leal, Maldonado-Carreno, Devine, & Szucs, 2016), MA studies throughout the past five decades have consistently reported that females in high school and colleges have statistically significant higher MA scores than their male counterparts. Betz (1978) surveyed university math and psychology students using a subscale of the Fennema-Sherman Math Attitudes Scale and found the mean female score to be higher than the mean for males. Bessant's (1990) study of MA structure, which included 173 university students, also showed sex differences in MA, with a mean female Math Anxiety Rating Scale score of 184.59 and a mean male score of 169.56 ($p = .05$). As part of some preliminary work for an experimental study, Hopko (2003) found Revised Math Anxiety Rating Scale scores for females to be higher than that of males in the 814-participant sample ($p < .001$).

This phenomenon is not only a reality in the United States. Sex differences in MA levels are common internationally. Cipora, Szczygiel, Willmes, and Nuerk (2015) conducted a validity study of the Polish version of the Abbreviated Math Anxiety Scale with 857 university students in Poland. These researchers found statistically significant ($p < .001$) higher AMAS scores among the female participants ($M = 22.6$), as compared to the male participants ($M = 18.9$). A small sample ($n = 34$) from a Ghanaian junior high school was studied to investigate the effects of corporal punishment and MA on math performance. Even in this small group, the difference in MA means for males and females was statistically significant ($p < .05$), with female MA higher than male MA (Nyarko, Kwarteng, Akakpo, Boateng, & Adjekum, 2013). Math anxiety levels also differed for males and females in a study of Italian high schoolers. Wang, Shakeshaft, Schofield, and Malanchini (2018) disseminated the Abbreviated Math Anxiety Scale to a sample of 437 male and 490 female students. Mean MA score was higher for females than for males ($p < .05$).

Given these examples from the literature, it is not surprising that the current study yielded similar results. The population in the current study, precalculus algebra course students from rural, small-to-medium community colleges in North Carolina, demonstrated differences in MA with respect to biological sex. Math anxiety researchers have studied and reported many reasons why the male-female disparity is especially pervasive. Lower female spatial processing ability (Maloney et al., 2012), perceived gender roles accompanied by parent-to-child transmission of these stereotypes (Gunderson et al., 2012), and poorer female math competency beliefs, such as math self-concept and math self-efficacy (Hill et al., 2016) are just a few of the cited explanations.

The difference in MA levels for high school and college male and female students hints that the effect of an intervention may differ based on the biological sex of the study participant. Additionally, the structure of MA is different between the sexes (Wilder, 2012), suggesting that a treatment for MA may generate different outcomes for males and females. This concept will be explored as the final null hypothesis is discussed.

Research Question and Null Hypothesis Three

The last research question in this study explored whether there is an interaction effect between online math module participation and biological sex on the mean math anxiety scores of community college students. The null hypothesis was "There is no significant interaction between online math module participation and biological sex with regard to the mean math anxiety scores of community college students." Results from the ANOVA analysis were not statistically significant, $F(1, 99) = .644$, $p = .424$, partial $\eta^2 = .006$, as shown in Table 4.7. This resulted in a failure to reject this hypothesis. Therefore, the study was unable to show any type of differential effect of the online math intervention on male and female student MA.

Though the results were not statistically significant, the means of each of the four groups in the interaction analysis suggested some variable impact of LGR on MA. The four groups – treated males, treated females, control males, and control females – and their corresponding MA mean scores, are shown in Table 4.4. The mean MA score for females was higher when they did not participate in the Let's Go Racing online math intervention. Conversely, the mean MA score for males was higher when they participated in the LGR intervention. If the interaction effect had been significant, the resultant means would have suggested that online math module participation may reduce MA in females, while increasing MA in males.

It is worthwhile to discuss previous intervention studies for which results indicated a different effect on male and female MA. In one example, Harding (2015) studied the effect of cooperative learning instruction on MA in university statistics course students. While no statistically significant effect was found for males, female students appeared to benefit from cooperative learning over traditional instructional methods. Though not a direct reference to interventions for MA, a recent study of math achievement differences based on instructional environment supports the notion that biological sex plays a role in how an intervention may influence student learning of mathematical concepts. Bowe, Desjardins, Covington Clarkson, and Lawrenz (2017) observed a positive difference in math achievement in urban African American females who were placed in single-sex classrooms. This effect was not observed in their male counterparts placed in single-sex classrooms.

With the limited availability of articles about the sex-related impact of MA interventions, an alternative explanation of the seemingly biological sex associations suggested in the current study should be considered. Given that females in high school and postsecondary education settings generally experience higher levels of math anxiety (the current study; Cipora et al., 2015; Hopko, 2003; Wang et al., 2018), the varying effect of an intervention may be due to the

MA level of a female group versus the male group within a study. In other words, biological sex may not be as important a factor in the effect of an intervention as is a participant's initial MA level. The work of Brunye et al. (2013) supports this notion. In this study of the effect of different types of breathing exercises on math performance, improvement in math accuracy was found for high math-anxious individuals who practiced focused breathing. The low math-anxious participants experienced no statistically significant improvement in accuracy on the same math problems.

The Henslee and Klein (2017) study of the effect of brief guided imagery on undergraduate MA reported no differences in the MA decrease for high versus low math-anxious individuals. However, in a study of a much younger population of California third graders, Supekar, Iuculano, Chen, and Menon (2015) found that an eight-week cognitive tutoring program "reduces math anxiety in high math-anxious children" (p. 12578). No effect of the intervention was observed in the low math-anxious study participants. Comparably, the nonsignificant results of the current study's interaction hypothesis suggest that Let's Go Racing affected males and females differently. Whether that effect is due to initial MA level, another sex-related characteristic, or a combination of factors remains unclear.

Implications

Previous research shows MA's effects on math performance (Carey et al., 2015), math avoidance (Furner & Gonzalez-DeHass, 2011), and academic and career path choices (Tariq & Durrani, 2012) are significant. This justifies the vast array of MA treatment studies that have aimed to elucidate timely, cost-effective, and practicable interventions for MA reduction. The current study found statistically significant differences in MA scores between male and female community college Math 171 students. However, no difference in MA levels was detected between students who completed the Let's Go Racing (LGR) online math intervention and those who did not. Similarly, there was no statistically significant interaction effect between biological sex and LGR participation. These results suggest that while the study supports existing literature regarding the generally higher levels of MA among females versus males, it did not provide promising evidence of a MA-reducing treatment for community college precalculus algebra students.

What should be highlighted however, is the potential for interventions to have different impacts on different groups of students. In other words, while the results were not statistically significant, mean MA levels for female students who completed the online math intervention were lower than the mean MA levels of females who did not. The opposite was true for males. Males who completed the online math intervention showed higher levels of MA than those who did not. These findings suggest that when MA treatments are designed and tested, they may need to be more customized to particular populations. Educators and investigators should avoid a one-size-fits-all mentality when planning and testing interventions.

This study was unique for several reasons. The intervention under examination was a mastery learning-based set of online modules, designed specifically for community college students entering their first college-level math courses. It was then tested for its effects to reduce MA in a sample of community college students. This combination of MA intervention and target group have yet to be reported in the literature. The results of the study are important to the existing body of literature, because they hint that the short-term Let’s Go Racing intervention in a postsecondary educational setting may be too little, too late.

The deleterious effects of MA likely accumulate within an individual over time. Strawderman’s (1985) math anxiety model supports this notion as the less desirable ends of the Feelings and Achievement continua (anxiety and failure, respectively) mutually influence each other (see Figure 1.1). Years of the cumulative effects of high MA and low math performance naturally become more difficult to reverse. Neurodevelopmental researchers Young et al. (2012) support early identification and treatment as best practices for successful MA reduction. It may therefore be more beneficial to target younger populations with MA-reducing and MA-preventive strategies, so that efforts are leveraged on individuals who have had less time to accumulate math-related anxieties and failures.

Limitations

It is not uncommon for educational researchers to choose a quasi-experimental design when investigating the potential impact of an intervention. Gall et al. (2007) justify the use of these designs in field research, asserting that it is not always feasible to randomly sort participants from educational settings into treatment and control groups. The current study employed a quasi-experimental 2 x 2 factorial posttest only design. Therefore, results should be considered in light of the potential threats to validity inherent in this design. Issues that were more procedural in nature and not necessarily a result of study design are also examined.

Threats to Internal Validity

Warner (2013) describes internal validity as “the degree to which the results of a study can be used to make causal inferences” (p. 17). To ensure an acceptable degree of internal validity, researchers should endeavor to control extraneous variables. The internal validity of the current study was compromised by several factors.

First, treatment and control groups were not randomly assigned. Instead, all study participants from one community college comprised the treatment group, while the control group was made up of students from a different community college. The treatment group site was chosen because the institution already employed the Let’s Go Racing online math intervention as part of its Math 171 – Precalculus Algebra course. The control group site was selected based on the similarities to the treatment site student population. The schools were demographically similar in student ethnicity, biological sex, and age percentages. However, this convenience sampling methodology prohibits the ability to assume groups are equivalent on all relevant characteristics (Warner, 2013) and introduces the possibility of undetected confounding variables. Employing a truly experimental design could reduce this threat, though the feasibility and practicability of random assignment is questionable.

The absence of a pretest to assess MA prior to intervention participation also jeopardizes this study's internal validity. The intentional omission of a pretest was an effort to avoid issues with test sensitization, a problem that often occurs when an instrument is administered more than once during a study (Warner, 2013). Without pretest scores, it is impossible to control for preexisting levels of MA in treatment and control group participants. To improve internal validity with respect to this issue, a pretest of MA followed by analysis of covariance statistical methodology should be performed. Results would then account for participant MA levels prior to intervention.

The remaining two internal validity threats pertain to the administration of the Math Anxiety Scale – Revised (MAS-R), the assessment instrument chosen for this study. First, the MA assessment instrument was disseminated via two different means. To maximize student participation, students at the control site were given an option of completing the MAS-R either electronically or on paper. An uneven distribution of assessment instrument delivery methodology may have affected study results. While all participants at the treatment site completed the MAS-R electronically after participating in the online math intervention, four of the six sections of Math 171 at the control site institution completed the MAS-R on paper. The remaining two sections completed the survey electronically. To avoid validity issues that may have resulted from this practice, the MAS-R instrument should have been administered either electronically or in hard copy form, but not both.

The final internal validity concern is the timing of the MAS-R distribution. The original plan was to deliver it to treatment and control group participants on the eighth calendar day of the precalculus algebra course – the day after the Let's Go Racing online math intervention was to be completed by the treatment group. The purpose of this timing was to reduce the influence of extraneous variables such as time exposed to math course lessons and evaluations and differing material between math class sections and institutions. Unfortunately, all participants did not complete the MAS-R on the eighth day after class start. Completion of the MA assessment instrument occurred between Day 8 and Day 42 of the course sections. This allowed time for other factors to influence participant MA levels. The MAS-R completion period was extended to increase participation. Perhaps a better way to improve the size of the study population would have been to invite other institutions to participate in the study while limiting the MA assessment period to an amount of time that would hinder the influence of extraneous variables.

Threats to External Validity

While quasi-experimental studies fail to provide optimum internal validity, they excel in their ability to produce externally valid results. Warner (2013) contends that the convenience sampling in quasi-experimental field studies aids in the generalizability of study results to real-world populations. Still, the current study retains two issues of external validity that should be discussed.

The first of these is the Hawthorne effect, described by Gall et al. (2007) as when "experimental conditions are such that the mere fact that individuals are aware of participating in an experiment… improves their performance" (p. 390). The Liberty University Institutional Review Board (IRB) requires that study participants be fully informed of their rights with respect to research study participation. The participant consent form for this study included the purpose of the study, study components, potential risks and benefits, and other information (see Appendix G). As a result, participants were fully informed of the study details, and could even infer whether they were in the treatment or control group. These informed participants may have completed the MAS-R assessment differently had they not been part of a research study.

The demographic characteristics of the study sample pose another threat to external validity. Population validity, a specific type of external validity, may be an issue for this study, because the participants were predominantly White, female, and ages 18 to 20. Additionally, both institutions in the current study were rural, small-to-medium-sized North Carolina community colleges. Gall et al. (2007) described population validity as an issue when study outcomes may only apply to the study sample rather than to the entire population represented by the sample. Results should therefore be applied cautiously to students in different community college settings and to postsecondary education students in general.

Recommendations for Future Research

With the current study only hinting at the potential for the online math intervention to positively affect math anxiety (MA) levels in female community college students, additional research regarding MA interventions is warranted. Recommendations for future research that would further increase knowledge of MA and interventions to alleviate its effects are listed here:

1. Include data collection of math success. Since the Let's Go Racing online math intervention has been shown to be associated with math success for community college gateway math course students (Myers et al., 2016), and since this information influenced the belief that the improvement in math success was likely due in part to a reduction of MA, a study including a measurement of math success as a variable may help to establish this connection. Including this covariate would provide data to

either support or weaken the notion that MA level is a mediating variable in student achievement.

2. Only include students from one course delivery methodology, such as fully seated or fully online. Seated courses generally have higher success rates than online courses (Bawa, 2016; Jaggars & Xu, 2016), and these varying instructional methodologies may have different effects on student anxiety. A study of only online students or only seated students would remove the potential influences of teaching methodology on MA, thereby resulting in a more internally valid study.
3. Study the effects of Let's Go Racing (LGR) in other gateway math courses. The current study focused on the MA of students in precalculus algebra courses. North Carolina community colleges offer two additional gateway math courses, Quantitative Literacy and Statistical Methods I. Let's Go Racing designers have created a version of the online math modules specific to the prerequisite skills of each of these gateway math courses. These versions were also associated with increased student success rates (Myers et al., 2016). A comparative study of the effects of LGR on the MA levels for students in each of the three North Carolina community college gateway math courses may reveal unique impacts on MA level based on course.
4. Study the effects of the online math intervention on MA using a larger study sample. Resultant means from the interaction hypothesis analysis in the current study did not vary with any statistical significance. However, their differences suggest an opposite effect of LGR on male student MA versus female student MA. A study that includes a larger sample size, $n = 144$ as suggested by Gall et al. (2007) for statistical power of .7, might yield statistically significant results.

The current study could be replicated in community colleges in different geographic regions of the United States. Universities would also serve as useful sites for which to study the Let's Go Racing online math intervention on MA levels. However, given the previous discussion regarding the greater potential for effective MA interventions in middle and secondary school-age students versus college students, efforts may need to be focused on younger populations. For example, practitioners and researchers would need to develop a version of the online math intervention for a high school math course such as geometry, and then assess its impact on geometry student MA levels.

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APPENDIX A

Permission to Use Strawderman (1985) Math Anxiety Model Figure

Reply all | Delete Junk | ...

RE: Request to use Figure from Dissertation (Strawderman, 1985)

WT [redacted] [redacted]@gsu.edu>

Today, 3:10 PM

Love, Rita; [redacted]@gsu.edu>; [redacted]@gsu.ed

Reply all |

Inbox

You replied on 8/1/2018 3:17 PM.

Dear Rita,

Thank you for your request for permission to use a figure from one of our dissertations. We especially appreciate your patience as we worked through the nuances of this particular request. Normally, we find the author of the manuscript (in this case a dissertation) and seek permission from that person first before granting an institutional permission. As you now know, Dr. Strawderman has passed away.

Given that Dr. Strawderman cannot provide permission, we grant you permission from the College of Education & Human Development at Georgia State University to use the figure you have described. We wish you the best of luck with your research and the completion of your degree. Please let me know if you have any questions.

Best wishes,

[redacted], Ph.D., FACSM, FAACVPR
President, American College of Sports Medicine (2017-2018)

Associate Dean for Graduate Studies and Research
Regents' Professor of Kinesiology and Health
Senior Advisor, After-School All-Stars Atlanta
College of Education & Human Development
Regents' Professor of Nutrition (College of Nursing and Health Professions)
Regents' Professor of Public Health (School of Public Health)
Georgia State University
Atlanta, GA USA 30302-3980

Telephone:
+4[redacted]

Mail:
P.O. Box 3980
Atlanta, GA USA 30302-3980

Courier or Express Mail:

Reply all | Delete Junk | ...

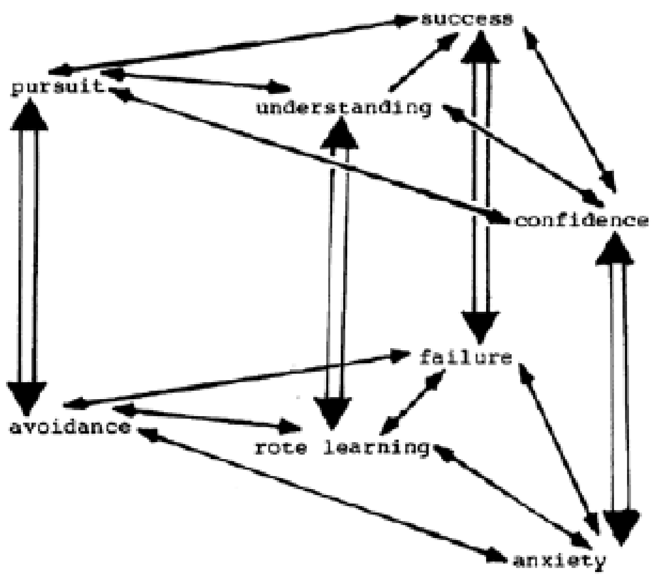
College of Education
Offices of the Dean
Atlanta, GA USA 30303

From: Love, Rita [mailto:[redacted].edu]
Sent: Wednesday, July 25, 2018 12:42 PM
T[redacted]n <[redacted]su.edu>
Subject: Request to use Figure from Dissertation (Strawderman, 1985)

Greetings, Dr. [redacted]n.

My name is Rita W. Love, and I am a Doctorate of Education student with Liberty University. I have completed my dissertation research on the topic of math anxiety, and I referenced Dr. Virginia Strawderman's dissertation in my manuscript repeatedly. Dr. Strawderman's dissertation was completed in 1985 as part of the requirements for Georgia State University's PhD in Educational Leadership Program.

I am requesting permission to use Dr. Strawderman's diagram of her math anxiety model in my dissertation. I am referring to the one shown here (found on p. 144 and labeled as Figure 32 in her dissertation):



Please consider my request allowing me to use this diagram in my dissertation. I look forward to hearing from you.

Reply all | Delete Junk | ...

Rita W. Love, Candidate
Doctorate of Education in Educational Leadership
Liberty University
70[redacted]

APPENDIX B

Parental Consent Form for Study Participation

The Liberty University Institutional
Review Board has approved
this document for use from
1/3/2018 to 1/2/2019
Protocol # 3084.010318

PARENT/GUARDIAN CONSENT FORM

The Effects of an Online Math Intervention on the Math Anxiety Levels of
Community College Students
Rita W. Love
Liberty University
School of Education

Your child is invited to be in a research study of math anxiety levels of college math students. He or she was selected as a possible participant because of his or her enrollment in a Math 171 – Precalculus Algebra class at a community college. Please read this form and ask any questions you may have before agreeing to allow him or her to be in the study.

Rita W. Love, a doctoral candidate in the School of Education at Liberty University, is conducting this study.

Background Information: The purpose of this study is to investigate the impact of the "Let's Go Racing" preparatory module on math anxiety in male and female college math students.

Procedures: If you agree to allow your child to be in this study, I would ask him or her to do the following thing:

1. Complete the Math Anxiety Scale-Revised (14 items), 4 demographic questions, and 1 procedural question on or around Day 8 of the class. This should take the student a maximum of 10 minutes.

   Note: Depending on the Math 171 course requirements of his or her community college, your child may or may not be asked to complete the "Let's Go Racing" preparatory modules. Students from colleges that provide and require "Let's Go Racing" as part of the Math 171 course are assigned to the experimental group for this study. Students from colleges that do not provide or require "Let's Go Racing" as part of the Math 171 course are assigned to the control group for this study.

Risks: The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

Benefits: Participants should not expect to receive a direct benefit from taking part in this study. Benefits to society include a greater understanding of interventions that may reduce college student math anxiety.

Compensation: Your child will not be compensated for participating in this study.

Confidentiality: The records of this study will be kept private. In any sort of report I might publish, I 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.

The Liberty University Institutional
Review Board has approved
this document for use from
1/3/2018 to 1/2/2019
Protocol # 3084.010318

- Participation will be anonymous. All research study data will be kept secure. Actual survey responses will be housed securely on the servers of the SurveyMonkey platform according to the privacy policy provided here (https://www.surveymonkey.com/mp/policy/privacy-policy/).

- Subsequent data files, electronic or otherwise, will be kept in a secure, password-protected environment at the researcher's home office. Data may be used in future presentations. The data will be kept for three years and then will be destroyed.

Voluntary Nature of the Study: Participation in this study is voluntary. Your decision whether or not to allow your child to participate will not affect his or her current or future relations with Liberty University or his or her community college. If you decide to allow your child to participate, he or she is free to not answer any question or to withdraw at any time prior to submitting the survey without affecting those relationships.

How to Withdraw from the Study: If your child chooses to withdraw from the study, your child should exit the survey and close his or her internet browser. Your child's responses will not be recorded or included in the study.

Contacts and Questions: The researcher conducting this study is Rita W. Love. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at 704-984-2229 or rlove22@liberty.edu. You may also contact the researcher's faculty advisor, Dr. Nathan Putney, at nputney@liberty.edu.

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 Institutional Review Board, 1971 University Blvd, Green Hall 1887, Lynchburg, VA 24515 or email at irb@liberty.edu.

Please notify the researcher if you would like a copy of this information for your records.

Statement of Consent: I have read and understood the above information. I have asked questions and have received answers. I consent to allow my child to participate in the study.

(NOTE: DO NOT AGREE TO ALLOW YOUR CHILD TO PARTICIPATE UNLESS IRB APPROVAL INFORMATION WITH CURRENT DATES HAS BEEN ADDED TO THIS DOCUMENT.)

____
Signature of Minor Date

____
Signature of Parent Date

____
Signature of Investigator Date

If you agree to allow your child to participate in this study, please print, sign and return this consent form to the child's instructor within one week of your child's class start date by employing one of the following options:

- give the signed consent to your child to physically submit it to his or her instructor;
- scan and email the signed consent to your child's instructor at instructor@email.edu;
- take a picture of the signed consent and text to your child's instructor at 555-555-5555 or email it to instructor@email.edu

APPENDIX C

Permission to Use the Math Anxiety Scale – Revised

RE: Request for Permission to Use Math Anxiety Scale - Revised

HB

Haiyan Bai [redacted]@ucf.edu>

Reply all|

Today, 12:50 PM

Love, Rita

Inbox

Hi Rita,

You have my permission to use it. I appreciate if you could share your study results with me.
Best,
Haiyan Bai

===================================

Haiyan Bai, Ph.D.
Associate Professor
Quantitative Methodology
Dept. of Educational and Human Sciences
College of Education & Human Performance
University of Central Florida
222J Education Complex
PO Box 16125
Orlando, FL 32816-1215
Fax:(407)823-4880
Methodology Measurement and Analysis Ph.D. Program:
http://www.ucf.edu/academics/methodology-measurement-and-analysis/

From: Love, Rita [mailto:rlove22@liberty.edu]
Sent: Tuesday, November 29, 2016 9:53 AM
To: Haiyan Bai [redacted]ucf.edu>
Subject: Request for Permission to Use Math Anxiety Scale - Revised

Greetings, Dr. Bai.

I am Rita W. Love, a doctoral student in Liberty University's Ed.D. in Educational Leadership Program. I am writing you today to request your permission to use the Math Anxiety Scale - Revised as the primary instrument in my dissertation research. The purpose of my study, "The Effects of Let's Go Racing on the Math Anxiety Levels of Community College Students," is to investigate whether Let's Go Racing (LGR), online modules completed at the beginning of a post-secondary precalculus algebra course that have been shown to improve student success, also has an effect on math anxiety levels.

Using a quasi-experimental 2 x 2 factorial post-test only design, four class sections will complete LGR after which they will complete the MAS-R. The non-equivalent control group will consist of four class sections not receiving LGR, but completing the MAS-R within a comparable time frame. Data will be analyzed using a two-way ANOVA, with independent variables being LGR participation (yes, no) and biological sex (male, female).

The high psychometric quality and bidimensionality of MAS-R (Bai, Wang, Pan, & Frey, 2009) was determined in a sample of community college students, and the 14-item length is practicable for my study participants. I appreciate the work that you and your colleagues have done to create and validate this instrument. I would like to add a few demographic questions, such as biological sex, age group, and ethnicity. I respectfully ask your permission to utilize the MAS-R in my study, which should enter the IRB process in Summer of 2017 and officially begin in Fall of 2017.

Thank you for your consideration. I look forward to hearing from you.

Sincerely,

Rita W. Love
Liberty University Student
70[redacted]
[redacted]rty.edu

APPENDIX D

Liberty University Institutional Review Board Approval Letter

LIBERTY UNIVERSITY
INSTITUTIONAL REVIEW BOARD

January 3, 2018

Rita Love

IRB Approval 3084.010318: The Effects of an Online Math Intervention on the Math Anxiety Levels of Community College Students

Dear Rita Love,

We are pleased to inform you that your study has been approved by the Liberty University IRB. This approval is extended to you for one year from the date provided above with your protocol number. If data collection proceeds past one year, or if you make changes in the methodology as it pertains to human subjects, you must submit an appropriate update form to the IRB. The forms for these cases were attached to your approval email.

Thank you for your cooperation with the IRB, and we wish you well with your research project.

Sincerely,

[redacted]

[redacted] **A, CIP**
Administrative Chair of Institutional Research
The Graduate School

LIBERTY
UNIVERSITY.
Liberty University | Training Champions for Christ since 1971

APPENDIX E

Treatment Site Approval Letter

[redacted]

[redacted]

October 23, 2017

Rita W. Love
EdD Student
Liberty University
[redacted]

Dear Rita W. Love:

After careful review of your research proposal entitled The Effects of Let's Go Racing on the Math Anxiety Levels of Community College Students, we have decided to grant you permission to conduct your study at [redacted]e, that involves disseminating the Math Anxiety Scale-Revised (with demographic items) instrument to Spring 2018 Math 171 students.

Check the following boxes, as applicable:

☐ Data will be provided to the researcher stripped of any identifying information.

☒ We are requesting a copy of the results upon study completion and/or publication.

Sincerely,

[redacted]

[redacted]ee
Vice President of Strategic Planning & Compliance
on behalf of [redacted]ecutive Leadership Team

Serving [redacted]r Over Forty-Five Years
AN EQUAL OPPORTUNITY – AFFIRMATIVE ACTION COLLEGE

APPENDIX F

Control Site Approval Letter

[redacted]Community College

Nov. 20, 2017

Rita W. Love
EdD Student
Liberty University
[redacted]

Dear Rita W. Love:

After careful review of your research proposal entitled The Effects of Let's Go Racing on the Math Anxiety Levels of Community College Students, [redacted] Administrative Council has decided to grant you permission to conduct your study at [redacted]mmunity College, that involves disseminating the Math Anxiety Scale-Revised (with demographic items) instrument to Spring 2018 Math 171 students.

Check the following boxes, as applicable:

√ Data will be provided to the researcher stripped of any identifying information.

√ I/We are requesting a copy of the results upon study completion and/or publication.

Sincerely,

[redacted]

[redacted]h
Dean, Planning & IE
[redacted]ity College
[redacted]c.edu

APPENDIX G

Participant Consent Form for Study Participation

The Liberty University Institutional
Review Board has approved
this document for use from
1/3/2018 to 1/2/2019
Protocol # 3084.010318

PARTICIPANT CONSENT FORM

The Effects of an Online Math Intervention on the Math Anxiety Levels of
Community College Students
Rita W. Love
Liberty University
School of Education

You are invited to be in a research study of math anxiety levels of community college students. You were selected as a possible participant because you are enrolled in a Math 171 – Precalculus Algebra class at a community college. Please read this form and ask any questions you may have before agreeing to be in the study.

Rita W Love, a doctoral candidate in the School of Education at Liberty University, is conducting this study.

Background Information: The purpose of this study is to investigate whether online preparatory modules designed to improve student course success also have an effect on the math anxiety levels of male and female community college students.

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

1. Complete the Math Anxiety Scale-Revised (14 items), 4 demographic questions, and 1 procedural question on or around Day 8 of the class. This should take the student a maximum of 10 minutes.

   Note: Depending on the Math 171 course requirements of your community college, you may or may not be asked to complete the "Let's Go Racing" preparatory modules. Students from colleges that provide and require "Let's Go Racing" as part of the Math 171 course are assigned to the experimental group for this study. Students from colleges that do not provide or require "Let's Go Racing" as part of the Math 171 course are assigned to the control group for this study.

Risks: The risks involved in this study are minimal, which means they are equal to the risks you would encounter in everyday life.

Benefits: Participants should not expect to receive a direct benefit from taking part in this study. However, general benefits to society include a greater understanding of interventions that may reduce college student math anxiety.

Compensation: Participants will not be compensated for participating in this study.

Confidentiality: The records of this study will be kept private. In any sort of report I might publish, I will not include any information that will make it possible to identify a participant. Research records will be stored securely, and only the researcher will have access to the records.

- Participation will be anonymous. All research study data will be kept secure. Actual survey responses will be housed securely on the servers of the SurveyMonkey platform according to the privacy policy provided here (https://www.surveymonkey.com/mp/policy/privacy-policy/).

- Subsequent data files, electronic or otherwise, will be kept in a secure, password-protected environment at the researcher's home office. Data may be used in future presentations. The data will be kept for three years and then will be destroyed.

Voluntary Nature of the Study: Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with Liberty University or your community college. If you decide to participate, you are free to not answer any question or to withdraw at any time prior to submitting the survey without affecting those relationships.

How to Withdraw from the Study: If you choose to withdraw from the study, please exit the survey and close your internet browser. Your responses will not be recorded or included in the study.

Contacts and Questions: The researcher conducting this study is Rita W. Love. You may ask any questions you have now. If you have questions later, **you are encouraged** to contact her at 704-984-2229 or rlove22@liberty.edu. You may also contact the researcher's faculty advisor, Dr. Nathan Putney, at nputney@liberty.edu.

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 Institutional Review Board, 1971 University Blvd., Green Hall Ste. 1887, Lynchburg, VA 24515 or email at irb@liberty.edu.

Please notify the researcher if you would like a copy of this information for your records.

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

(NOTE: DO NOT AGREE TO PARTICIPATE UNLESS IRB APPROVAL INFORMATION WITH CURRENT DATES HAS BEEN ADDED TO THIS DOCUMENT.)

APPENDIX H

Recruitment Material Item

Email Message Templates for Math 171 Students

Message 1 (Control Group)

Hi, Students. Welcome to Week 2 of Math 171 – Precalculus Algebra. Please take a moment to participate in a research study involving community college math students. Participation is voluntary, but your confidential responses to the short survey will provide valuable information regarding math anxiety and its potential to be alleviated.

Visit this link to begin – [LINK HERE]

Note: If you are 17 or under, a parent or guardian must have already approved your participation by signing the parental consent form. Students 18 and over provide their own consent.

Thank you, and have a great day!

Message 2 (Treatment Group)

Hi, Students. Welcome to Week 2 of Math 171 – Precalculus Algebra. Now that you have completed your Let's Go Racing modules, please take a moment to participate in a research study involving community college math students. Participation is voluntary, but your confidential responses to the short survey will provide valuable information regarding math anxiety and its potential to be alleviated.

Visit this link to begin – [LINK HERE]

Note: If you are 17 or under, a parent or guardian must have already approved your participation by signing the parental consent form. Students 18 and over provide their own consent.

Thank you, and have a great day!

APPENDIX I

Math 171 Instructor Training Information

Thank you for agreeing to assist with the implementation of this research study. My name is Rita W. Love, and I am a doctoral candidate in the Liberty University Doctorate of Education in Educational Leadership Program. This document serves to orient participating Math 171 faculty with the Let's Go Racing/Math Anxiety Study and to explain the process necessary for its successful execution. I will be contacting you within one week of sending you this information, so that we can discuss any questions or concerns you may have. However, anytime you have questions, feel free to contact me at 704-984-2229 or ritawlove@gmail.com.

Name of the Study:

The Effects of an Online Math Intervention on the Math Anxiety Levels of Community College Students

Purpose of the Study:

The purpose of this study is to investigate whether online preparatory modules designed to improve student course success (Let's Go Racing) also have an effect on the math anxiety levels of male and female community college students.

Instructor Responsibilities (Control Group):

Students registered for any Spring 2018 Math 171 course section at your institution will be given the opportunity to participate in the control group for this study. These students will be asked to complete a math anxiety and student demographic questionnaire (MAS-R).

On or about the eighth calendar day after the Math 171 course section has begun, the instructor will instruct students to access the study consent form and MAS-R instrument, available at this link [add link here]. Classes with no seated component will receive these instructions electronically.

The completion of the consent form and MAS-R must be entirely voluntary, in accordance with standard Institutional Review Board procedure. Therefore, instructors should understand the importance of not incentivizing student completion of MAS-R by associating it with a course grade. However, if students question the importance of completing these components, it is appropriate to answer that student participation will help lead to a greater understanding of college student math anxiety.

Instructor Responsibilities (Treatment Group):

Students registered for any Spring 2018 Math 171 course section at your institution will be given the opportunity to participate in the treatment group for this study. These students will be asked to complete a math anxiety and student demographic questionnaire (MAS-R) after they have completed the Let's Go Racing modules.

On or about the eighth calendar day after the Math 171 course section has begun, the instructor will instruct students to access the study consent form and MAS-R instrument, available at this link [add link here]. Classes with no seated component will receive these instructions electronically.

The completion of the consent form and MAS-R must be entirely voluntary, in accordance with standard Institutional Review Board procedure. Therefore, instructors should understand the importance of not incentivizing student completion of MAS-R by associating it with a course grade. However, if students question the importance of completing these components, it is appropriate to answer that student participation will help lead to a greater understanding of college student math anxiety.