MATHEMATICS SELF-EFFICACY AND ANXIETY QUESTIONNAIRE

by

DIANA K. MAY

(Under the Direction of Shawn Glynn and Denise S. Mewborn)

ABSTRACT

College mathematics achievement is often influenced by students' mathematics self-efficacy and mathematics anxiety. Consequently, instructors strive to build students' mathematics self-efficacy or alleviate mathematics anxiety, but instructors lack the tools to reliably, validly, and efficiently assess these constructs. A major goal of this study was to develop a reliable, valid, and efficient questionnaire to assess college students' mathematics self-efficacy and mathematics anxiety. This questionnaire, called the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ), was designed to assess each construct as a subscale of the questionnaire. Relationships among students' questionnaire responses and individual characteristics such as gender, high school mathematics preparation, and grades in college mathematics courses were examined. Interviews also were conducted with a random sample of the students to determine that the questionnaire was effective in assessing these constructs and to provide more insight into the quantitative findings. The questionnaire was found to be reliable, relatively valid, and efficient to administer. Correlations between items on the questionnaire and items on two other, established questionnaires, provided evidence of construct validity. Furthermore, an exploratory factor analysis of the students' questionnaire responses identified five clusters of items (factors) that indicated how the students conceptualized the items: general mathematics self-efficacy, grade anxiety, mathematics self-efficacy on assignments, mathematics for students' futures, and self-efficacy and anxiety in class. On the general mathematics self-efficacy factor, students who had passed their most recent precalculus exam were found to have higher mathematics self-efficacy and lower anxiety than students who had failed their most recent precalculus exam, providing additional evidence of construct validity. There were no differences found in MSEAQ scores due to gender or high school mathematics preparation. The mathematics self-efficacy and anxiety questionnaire that resulted from this study merits improvement and continued research. It will benefit researchers who wish to explore relationships among college students' mathematics self-efficacy, mathematics anxiety, other student characteristics, and criterion variables such as mathematics achievement. The questionnaire will also benefit instructors who wish to better understand their students' mathematics self-efficacy and anxiety in order to increase their students' achievement.

INDEX WORDS: Mathematics Self-efficacy, Mathematics Anxiety, College Mathematics, Motivation, Grade Anxiety

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by

DIANA K. MAY

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by

DIANA K. MAY

Major Professors:	Shawn Glynn Denise S. Mewborn
Committee:	Dorothy Y. White Jeremy Kilpatrick

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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DEDICATION

I would like to dedicate this dissertation to my husband, Brian. Thank you so much for your unending love and support.

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INTRODUCTION

Background and Rationale

As college mathematics instructors respond to the need for fostering students' mathematics literacy, the important role of students' mathematics self-efficacy has received increased attention (Hannula, 2006; Pape & Smith, 2002). Mathematics self-efficacy is commonly defined as individuals' beliefs or perceptions regarding their abilities in mathematics. Bandura (1997) suggested that students with higher levels of self-efficacy tend to be more motivated to learn and more likely to persist when presented with challenging tasks. Bandura identified four main sources of self-efficacy: mastery experiences, vicarious experiences, social persuasion, and physiological states. Students base most of their beliefs about their abilities on their mastery experiences. For example, students who have repeatedly succeeded in previous mathematics courses will most likely believe that they have the ability to succeed in future mathematics courses. Vicarious experiences involve students observing social models similar to themselves succeeding with particular tasks. Although this does not contribute as strongly to self-efficacy as mastery experiences, students will feel more confident in mathematics if they see students they perceive as similar to themselves succeeding in mathematics. The final two sources contribute the least to students' self-efficacy. Social persuasion refers to encouragement, both positive and negative, from peers, teachers, and parents. Physiological states refer to the student's physical state such as fatigue, pain, or nausea.

Poor mathematics self-efficacy in college students often decreases their motivation to learn and eventually can lead to low mathematics achievement. In a study of college freshmen enrolled in a developmental mathematics course, Higbee and Thomas (1999) found that mathematics self-efficacy, along with other affective factors such as test anxiety and perceived usefulness of mathematics, influenced students' mathematical performances. The results of their study suggest to instructors that focusing on teaching mathematical content is insufficient for some students to learn mathematics. College mathematics instructors must also consider emotional or attitudinal factors that influence how students learn mathematics.

Closely related to mathematics self-efficacy, mathematics anxiety can also affect students' performances in mathematics classes. Mathematics anxiety is related to general anxiety as well as test anxiety, but it also extends to a more specific fear of mathematics (Hembree, 1990; Kazelskis et al., 2000). As Richardson and Suinn (1972) point out: "Mathematics anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations" (p. 551). Mathematics anxiety can often affect students who, otherwise, do not generally experience anxiety in other academic subjects.

The impact of mathematics anxiety varies based on each individual student. Students who suffer from higher levels of mathematics anxiety typically develop negative attitudes and emotions toward mathematics. By the time students participate in college mathematics courses, their attitudes toward mathematics are relatively stable; those students with mathematics anxiety are more likely to avoid taking mathematics courses in college. Perhaps the most severe consequence of mathematics anxiety is a decreased level of mathematical achievement. Cates and Rhymer (2003) found that students with higher levels of mathematics anxiety had significantly lower computational fluency in all areas of mathematical computations; these students, in turn, had lower levels of achievement in mathematics.

Because mathematics self-efficacy and mathematics anxiety influence college students' mathematics achievement, it is important to understand how self-efficacy and anxiety relate to each other. Previous research has focused on measuring and exploring the two constructs separately. Because of the possible interrelationship between these two constructs, it would be beneficial to examine them together to answer questions such as the following. Do students with high levels of mathematics self-efficacy have low levels of mathematics anxiety? If college instructors reduce their students' mathematics anxiety, will the students' self-efficacy in mathematics increase? A strong relationship between mathematics self-efficacy and mathematics anxiety could have implications for how researchers understand and measure these constructs and how instructors attempt to improve students' attitudes toward mathematics. The questionnaires that are currently used in research on mathematics self-efficacy or anxiety were designed to be used as separate instruments for a variety of different purposes.

In order to investigate the relationship between mathematics self-efficacy and mathematics anxiety, researchers need a questionnaire especially designed to explore how these constructs relate to each other. The overall goal of this study was to develop a questionnaire that can be used to explore the relationship between mathematics self-efficacy and mathematics anxiety. The questionnaire can also be used to explore the relationship of self-efficacy and mathematics anxiety with other variables, such as gender, achievement, and prior coursework in mathematics. In particular, the questionnaire was developed to address the following research questions: (1) How are college students' mathematics self-efficacy and mathematics anxiety related to each other? and (2) How are college students' mathematics self-efficacy and mathematics anxiety related to students' gender, high school mathematics preparation, and college mathematics experiences?

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

To understand what types of items are appropriate for a questionnaire regarding college students' mathematics self-efficacy and mathematics anxiety, it is essential to understand how researchers define these constructs and what is currently known about them. After reviewing the literature on mathematics self-efficacy and mathematics anxiety, I present the theoretical framework for this study, a general expectancy-value model, along with how it relates to college mathematics students.

Mathematics Self-Efficacy

Mathematics self-efficacy is defined as an individual's beliefs or perceptions with respect to his or her abilities in mathematics (Bandura, 1997). In other words, an individual's mathematics self-efficacy is his or her confidence about completing a variety of tasks, from understanding concepts to solving problems, in mathematics. Self-efficacy, in general, has been linked with motivation. It has been well established that students with higher levels of self-efficacy tend to be more motivated to learn than their peers and are more likely to persist when presented with challenges (Pajares & Graham, 1999; Pajares & Kranzler, 1995; Zeldin, Britner & Pajares, 2008). Although the development of self-efficacy is not fully understood, researchers have consistently confirmed Bandura's (1997) four main sources of self-efficacy: mastery experiences, vicarious experiences, social persuasion, and physiological states (Hampton & Mason, 2003; Lopez & Lent, 1992; Usher & Pajares, 2009). In a study on designing a scale to explore the sources of mathematics self-efficacy, Usher and Pajares (2009) found that "perceived mastery experience is a powerful source of students' mathematics self-efficacy. Students who feel they have mastered skills and succeeded at challenging assignments experience a boost in their efficacy beliefs” (p. 100).

According to Bandura’s (1997) social cognitive theory, self-efficacy is specific to context and must be measured appropriately. For example, students might feel confident that they can correctly solve systems of linear equations but lack confidence in their abilities to prove a geometric theorem. In this situation, asking the students to rate their confidence in mathematics generally could result in misleading responses. Bandura also suggested that self-efficacy should be measured close to the time that the task would take place. This proximity helps students to make more accurate judgments about their abilities than otherwise. With these guidelines for measuring self-efficacy in mind, it is crucial to understand how researchers typically measure mathematics self-efficacy.

Measuring mathematics self-efficacy. The most commonly used scale for measuring mathematics self-efficacy is the Mathematics Self-Efficacy Scale (MSES) (Betz & Hackett, 1983). This scale was originally developed to explore gender differences in mathematics self-efficacy and how these differences affect students’ career choices. After reviewing previous research on mathematics anxiety and mathematics self-efficacy, Betz and Hackett identified three main domains involved with studying mathematics self-efficacy: solving mathematics problems, using mathematics in everyday tasks, and obtaining good grades in mathematics courses. The MSES asks participants to rate their confidence on a scale from 0 to 9 in their ability to perform 18 mathematics tasks, to correctly solve 18 mathematics problems, and to get a B or better in 16 mathematics-related college courses.

Although no factor analytic research has been conducted on the original MSES, Kranzler and Pajares (1997) used factor analytic techniques to analyze a revised version of the MSES, referred to as the Mathematics Self-Efficacy Scale-Revised (MSES-R) (Pajares & Miller, 1995). The items on the MSES-R were taken from the original MSES, but the mathematical problems were replaced by problems from arithmetic, algebra, and geometry taken from the Mathematics Confidence Scale (Dowling, 1978). Also, on the MSES-R, students rated their confidence on a scale from 1 to 5, not 0 to 9 as in the original MSES. Factor analysis revealed three factors of the MSES-R, as expected: mathematical problems, mathematical tasks, and mathematics courses. The courses, however, were split into two factors—pure mathematics courses and science courses that require a lot of mathematics. The identification of multiple factors of the MSES-R suggests that mathematics self-efficacy is conceptually more complex than Betz and Hackett (1983) believed.

Although a score can be computed for the MSES, Kranzler and Pajares (1997) cautioned researchers that it is difficult to assign and make appropriate use of an overall score for mathematics self-efficacy based on scales such as the MSES or MSES-R. It is important for researchers and educators to consider the multiple factors involved when assessing a student's level of mathematics self-efficacy. Because of the nature of mathematics self-efficacy, students can have, or lack, confidence in a multitude of areas involved with mathematics. If a student's score is lower on one factor than the rest of the factor scores on a mathematics self-efficacy scale, his or her overall score can be distorted, which can lead educators or researchers to misjudge the student's overall level of mathematics self-efficacy.

Research findings on mathematics self-efficacy. Many of the initial research studies conducted on college students' mathematics self-efficacy sought to explore how students' mathematics self-efficacy influenced their college major and career choices. Betz and Hackett (1983) developed the MSES, as discussed previously, specifically to determine how mathematics self-efficacy and gender influence students' choices of science-based college majors. Betz and Hackett found that an individual's mathematics self-efficacy plays a major role in deciding college majors; students with higher levels of mathematics self-efficacy were significantly more likely to choose science-based college majors than students with lower levels of mathematics self-efficacy. Mathematics self-efficacy has also been shown to be a predictor for students' career choices, with higher levels of mathematics self-efficacy being related to more science-based careers (Hackett & Betz, 1989).

Mathematics self-efficacy has also been associated with college students' mathematics achievement. In a study of college freshmen, Hall and Ponton (2002) set out to explore the differences between students enrolled in a developmental mathematics course and those enrolled in a calculus course. Not surprisingly, the developmental mathematics students had lower mathematics self-efficacy than the calculus students did. Hall and Ponton hypothesized that this finding supported Bandura's beliefs that mathematics achievement is the greatest source of self-efficacy. Developmental mathematics students are less likely to have previous successful mathematics achievement than calculus students and are therefore less likely to have higher levels of mathematics self-efficacy.

Although it has been established that college students with higher levels of mathematics self-efficacy tend to perform better in mathematics, the correspondence between mathematics self-efficacy and mathematics performance is still not completely understood. Studying college undergraduates enrolled in an introductory psychology course, Hackett and Betz (1989) found that students' levels of mathematics self-efficacy are a better predictor of their educational and career choices than the students' previous mathematics performance. Students' previous performance in mathematics contributes to their mathematics self-efficacy, but how students perceive that performance is more indicative of future performances than their actual achievement.

Researchers have also been interested in gender differences in mathematics self-efficacy. Unfortunately, research findings have been inconclusive regarding these differences. Some researchers have found a significant difference between the mathematics self-efficacy of male and female students, with males demonstrating significantly higher levels of mathematics self-efficacy than female students (Betz & Hackett, 1983; Pajares & Miller, 1994). These researchers hypothesized that females' lower levels of mathematics self-efficacy were a result of commonly held beliefs that mathematics is a male-dominated field or that women are not typically good at mathematics. These beliefs lead women to think that they should not be good at mathematics, regardless of their actual abilities. In contrast, some researchers have not found gender differences in mathematics self-efficacy (Cooper & Robinson, 1991; Hall & Ponton, 2002). In a study of undergraduates, Lent, Lopez, and Bieschke (1991) found a slight difference between the mathematics self-efficacy of men and women. They hypothesized that gender differences diminish when male and female students have comparable prior coursework experiences in mathematics. Hackett and Betz (1989) also suggested that the small gender differences they found were due, in part, to gender differences in mathematics performances.

Because mathematics self-efficacy influences students' mathematical achievement, researchers have been interested in how accurately students' mathematics self-efficacy corresponds to their actual abilities. Hackett and Betz (1989) found that students consistently estimate their abilities inaccurately. In their study of college undergraduates, the majority of male students' and a large minority of female students' beliefs about their abilities in mathematics were incongruent with their actual performances. Similarly, Pajares and Miller

(1994) found that college students tend to incorrectly estimate their abilities in mathematics, with 57% of the students overestimating their abilities and 20% underestimating. Although some overestimates can be beneficial to help students persist in mathematics, underestimates and gross overestimates can be harmful to students' mathematics achievement. Researchers have established different sources of mathematics self-efficacy, but more research is needed on how students develop inaccurate or misleading self-efficacy in mathematics.

Mathematics Anxiety

Mathematics anxiety can also affect students' motivation to learn in mathematics classes. Mathematics anxiety is related to students feeling tense or anxious when working with numbers or solving mathematical problems (Richardson & Suinn, 1972). Students who suffer from mathematics anxiety do not necessarily experience anxiety in other subjects. There are many negative consequences of mathematics anxiety. For example, students who experience higher levels of mathematics anxiety typically develop negative attitudes and emotions toward mathematics. By the time students reach college mathematics courses, their attitudes toward mathematics are relatively stable, and students with mathematics anxiety are less likely to take mathematics classes or pursue careers requiring mathematics. Perhaps the most severe consequence of mathematics anxiety is a decreased level of achievement. In a study on college undergraduates' mathematical performance, Cates and Rhymer (2003) found that students with higher levels of mathematics anxiety had significantly lower computational fluency in all areas of mathematical computations. This lower level of fluency in turn decreases students' achievements in mathematics and likely contributes to negative attitudes toward mathematics.

With the clear significance of mathematics anxiety for college students' mathematics achievement, it is important to consider how researchers go about studying such a complex construct. Before discussing research findings on mathematics anxiety, I present a brief review on how mathematics anxiety is typically measured, followed by a discussion of the scale most commonly used to study mathematics anxiety.

Measuring mathematics anxiety. The most widely cited scale used to measure and explore mathematics anxiety is the Mathematics Anxiety Rating Scale (MARS) (Suinn, 1972). Researchers suspected that some individuals who did not normally suffer from general anxiety were still affected by mathematics anxiety, so Suinn developed the MARS to look more specifically at mathematics anxiety. The purpose of the MARS was to help researchers explore mathematics anxiety and to evaluate mathematics-anxiety relief techniques. The scale consists of 98 items that address students' anxiety with the manipulation of numbers and mathematical concepts. The MARS has been used repeatedly by researchers to learn more about how mathematics anxiety affects students and to determine the effectiveness of intervention programs designed to alleviate mathematics anxiety (Bessant, 1995; Capraro, Capraro, & Henson, 2001; Llabre, 1984; Rounds & Hendel, 1980; Zettle & Houghton, 1998).

Multiple researchers have also explored the various dimensions of mathematics anxiety with the MARS using factor analysis. Rounds and Hendel (1980) found two primary factors of mathematics anxiety when using the MARS instrument: Mathematics Test Anxiety and Numerical Anxiety. The items from the MARS that load onto the Mathematics Test Anxiety factor deal with the anxiety students feel before, during, and after mathematics tests. Items that load onto the Numerical Anxiety factor are items that cover number manipulation involved primarily in arithmetic. Other researchers have also identified these two main factors through subsequent factor analyses with the MARS (Alexander & Martray, 1989).

The main criticism of the MARS is the large number of items on the scale. Several attempts have been made to reduce the number of items by omitting redundant or seemingly irrelevant items (Alexander & Martray, 1989; Levitt & Hutton, 1984; Rounds & Hendel, 1980). Many of the attempts to shorten the MARS have lacked appropriate generalizability or have failed to discuss how the items were altered. To establish a valid, shorter version of the MARS that could be used in a variety of settings, Suinn and Winston (2003) developed a 30-item scale based on the MARS. The 30 items included on the revised version of the MARS were selected from the original MARS scale based on factor loadings in previous studies; items with significant loadings on either the Mathematics Test Anxiety factor or the Numerical Anxiety factor were included on the revised version. The results of administering the revised version to introductory psychology students established that the revised version is valid, internally consistent, and comparable to the original scale.

One major difficulty in measuring mathematics anxiety is the influence society has on students' beliefs with respect to mathematics. In a study on the relationship between mathematics anxiety and social desirability, Zettle and Houghton (1998) found that college-age men are less likely than women to report feelings of anxiety toward mathematics because the men believe that it is socially unacceptable for men to experience mathematics anxiety. This finding suggests that researchers will have a more difficult time measuring the mathematics anxiety of male students than that of female students. Zettle and Houghton caution researchers and college administrators when using the MARS in situations that screen students for special intervention programs or other academic opportunities because research suggests that some students might be overlooked because of their unwillingness to truthfully respond to mathematics anxiety questions.

Research findings on mathematics anxiety. Considering the impact mathematics anxiety has on mathematical achievement, it is important to ask what causes mathematics anxiety. Jackson and Leffingwell (1999) asked 157 college students to reflect on their mathematical experiences from elementary school through college. Students were asked to identify challenging experiences in order to explore when they perceived themselves as being stressed in a mathematics class. About 27% of the students reported that their first stressful experiences in mathematics were at the college level. Students consistently identified experiences with their instructors as influencing their emotions and attitudes toward mathematics. These experiences included instructors' derogatory comments, negative attitudes and behavior toward their students, and lack of caring about students' understanding. Other researchers have also shown that teachers' attitudes toward both students and the courses they are teaching can influence how students respond to the material (Wilson & Thorton, 2005).

Another factor that contributes to students' mathematics anxiety is the type of instructional method used in the college classroom. Clute (1984) explored how two instructional methods, discovery and expository, interacted with students' mathematics anxiety in an undergraduate core curriculum mathematics course. Clute found that students with higher levels of mathematics anxiety scored higher on the achievement test if they were in the expository format course as opposed to the discovery format course. On the other hand, students with lower levels of mathematics anxiety performed better in the discovery course. Clute concluded that there is an interaction between mathematics anxiety and confidence. Students with higher levels of anxiety would have lower levels of confidence in mathematics and therefore would be less likely to perform well in courses where they would need the confidence to discover the mathematics for themselves. Therefore, the amount of confidence required on the student's part to learn the mathematical concepts was partially determined by the instructional method.

Little research has been conducted on how student characteristics, such as gender or high school experience, contribute to the development of college students' mathematics anxiety. Instead, researchers have focused their efforts on how mathematics anxiety interacts with students' performance. Initially, researchers believed that poor performance led to students feeling anxious about mathematics. They hypothesized that students with low achievement in mathematics would develop negative emotions and attitudes toward mathematics, causing them to avoid mathematics in the future (Hembree, 1990). This avoidance would cause students to continue performing poorly, confirming the students' emotions and attitudes toward mathematics. Once trapped in this vicious cycle, it would be difficult for students to alleviate their mathematics anxiety without some type of intervention.

Although this avoidance cycle is apparent with students who have higher levels of mathematics anxiety, there is little evidence to support low performance initiating or contributing to mathematics anxiety (Ashcraft, 2002). Hoping to find cognitive influences on mathematics anxiety that affect students as they work on mathematics problems, Ashcraft and Kirk (2001) investigated how students' working memory affected their levels of anxiety during mathematical tasks. Working memory, or short term memory, is the active part of the memory where information is temporarily stored and manipulated. Ashcraft and Kirk found that mathematics anxiety causes interference with the working memory's ability to focus on the mathematical task. For example, students who feel nervous while performing a mathematical task will have thoughts about their anxiety while working on the task. These thoughts take up part of the working memory's capacity, thereby decreasing the amount of working memory available for the mathematical task. Ashcraft and Kirk also found that this working memory interference not only causes students to take longer with mathematical tasks but also degrades students' accuracy.

Closely related to working memory interference is the observation that students often report feeling more anxious about mathematics during timed tests (Jackson & Leffingwell, 1999). Walen and Williams (2002) conducted a qualitative study on how two college students' mathematical performance suffered when time constraints were placed on mathematics tests. Although both students demonstrated their understanding of the material in class and on homework assignments, both failed exams in class when they only had a limited amount of time to work. After discussing their concerns about timed tests with their instructors, both were allowed to take the tests without time constraints. Without having to worry about how much time was left, the students both received excellent grades on their exams and managed to finish within the original time limit. Walen and Williams hypothesized that students' concerns about time interfere with their ability to focus on the mathematical tasks at hand. Worrying about the amount of time left can reduce the amount of working memory available to work on the mathematical problems.

More research is needed on how mathematics anxiety develops in students and how this development process might differ based on student characteristics, such as gender, ethnicity, classroom experiences, and socioeconomic status. It is difficult for researchers to determine when mathematics anxiety develops because students must be able to recognize when they are feeling anxious and identify the source of their anxieties. Also, as the difficulty of the mathematics increases, researchers have a hard time distinguishing between when students are suffering from mathematics anxiety and when they are simply less competent in mathematics

Ashcraft & Kirk, 2001). These difficulties need to be taken into consideration when designing studies on mathematics anxiety.

Theoretical Framework

Motivation is defined as an individual’s tendency to instigate and sustain goal-directed behaviors (Pintrich & Schunk, 2002). When it comes to learning mathematics, it is often assumed that highly motivated college students are more likely to achieve and perform at higher levels than less motivated students. It is also assumed that college students’ motivation to learn mathematics is related to their levels of mathematics self-efficacy and anxiety. Specifically, it is assumed that college students who feel more confident than their peers in their abilities in mathematics and have less anxiety toward mathematics are more likely to be motivated to learn and therefore succeed in mathematics (Middleton & Spanias, 1999). Unfortunately, research that actually tests these assumptions is sparse.

Most of the research conducted to date in mathematics motivation involves elementary and secondary school students. The college mathematics environment, being less structured, typically requires students to motivate themselves in their studies. Understanding how mathematics self-efficacy and anxiety play a role in motivation is crucial for encouraging college students to learn mathematics.

Because of the complex nature of motivation, there are multiple approaches to exploring an individual’s motivation to learn mathematics. One of the most common ways to conceptualize motivation is as extrinsic or intrinsic. Extrinsic motivation occurs when an individual is motivated to complete a task by a factor that is external to the task. For example, in school, students might be motivated to study for tests in order to receive a good grade. Intrinsic motivation is when an individual’s motivation comes from the task itself. In school, this can result from students being motivated to study for a test because of the satisfaction they receive when overcoming academic challenges.

Another way to characterize motivation is with respect to a student's goal orientation. Goals are typically classified as either learning goals or performance goals. When a student sets learning goals, the goals are related to successfully understanding the material, learning new skills, or mastering tasks. The desired result is not just to complete the task, but to have gained some type of understanding as well. Performance goals, on the other hand, lead a student to be concerned only with the outcome of the task. For example, students with performance goals will not necessarily strive for understanding concepts if they can achieve a satisfactory grade without learning the material.

Although extrinsic and intrinsic motivation, along with goal orientation, are important to academic motivation, the exploration of the relationship between mathematics self-efficacy and mathematics anxiety requires consideration of how these constructs affect student motivation based on students' beliefs. The framework utilized in this paper is a general expectancy-value model (Ajzen & Fishbein, 2005; Eklof, 2006; Wigfield, Tonks, & Eccles, 2004**),** which emphasizes the importance of individuals' beliefs about a variety of issues and how these beliefs interact to contribute to their motivation. This framework considers the individuals' beliefs about their abilities (expectancy components) and their beliefs about the value of the tasks (value components). To apply this framework to mathematics self-efficacy and mathematics anxiety, it is necessary to understand both of these components and how they apply to college mathematics students.

General Expectancy-Value Model

The general expectancy-value model is a representation of the factors that affect students' achievement motivation (Wigfield & Eccles, 2000). There are two kinds of components in the model: expectancy components and value components. These are explained in the following sections.

Expectancy components. The expectancy components of motivation consist of students' beliefs about their abilities to successfully complete specific tasks. Students are not likely to be motivated to attempt tasks if they do not believe they can successfully finish them. In mathematics, students who believe that they have the ability to complete a mathematics task typically demonstrate more persistence with the task, even when it becomes challenging. Students' beliefs about their abilities in mathematics can be affected by social or cultural norms. For example, a common stereotype in some societies is that women are not supposed to be as good at mathematics as men. When female students pick up on this belief from society, it can affect how they form their personal beliefs about mathematics (Beloff, 1992; Rammstedt & Rammsayer, 2000). Expectancy components of motivation in mathematics are clearly connected to students' levels of mathematics self-efficacy, or their confidence in their abilities to learn and understand mathematics.

Closely related to students' beliefs about their abilities is their locus of control. The locus of control is defined as the extent to which an individual believes he or she has control over the outcomes in different situations (Schunk, 2004). An individual's locus of control can come from either internal or external sources. Students with an internal locus of control believe that their behavior can directly influence their environment with specific desired results. They are more likely than other students to study and work hard to succeed in school because they believe that their efforts can result in achievement. Students with an external locus of control, however, believe that academic achievement is out of their control. Instead, they might believe that their achievement depends more on the effectiveness of the teacher or the difficulty level of the material.

At the college level, students with internal loci of control are more likely than others to graduate, especially in situations of distance learning (Morris, Wu, & Finnegan, 2005; Parker, 1999, 2003). On the other hand, students with an external locus of control believe that other people or environmental factors control their successes and failures. They are not as likely as others to persist in their college courses, but rather blame their results on teachers, fellow students, or other external factors. In mathematics, commonly held beliefs regarding mathematics can influence students' loci of control. To continue with the previous example, when female students are influenced by society to believe that women are not good at mathematics, they might develop an external locus of control and feel that their gender controls their ability to learn mathematics.

Value components. The value components of motivation consist of students' beliefs about how worthwhile specific tasks are or how valuable the results of the tasks will be. If students do not perceive the outcome of the task to be valuable, then they are not likely to attempt the task in the first place (Pintrich, 2004). Also, when students are faced with struggles or challenging tasks, they are not likely to persist if they do not feel that the task is worth the effort. These beliefs about the value of tasks can be influenced by the students' culture or society, with some cultures placing more value on certain tasks than other cultures. In a study based on results from 39 countries in the Third International Mathematics and Science Study, Shen (2001) found that the value a society placed on education, mainly of mathematics and science, affected students' academic achievement. Therefore, in order to be successful, educators pushing for mathematics reform must also consider the society's values of mathematics and science education and how these values can be altered, if needed.

In mathematics, it is also extremely important for students to see the need for the mathematics they are studying. College students taking lower-division (or introductory) mathematics courses are not typically majoring in mathematics and, therefore, would like to see how the material they are studying is relevant to their careers or everyday lives. Researchers have found contradictory results with respect to the direct influence of perceived value on mathematics performance. Lovell (1990) found that perceived usefulness of mathematics is a reliable predictor of achievement for college students. In contrast, Elliott (1990) found that students' perceptions of the usefulness of mathematics do not seem to have a significant impact on their achievement. Fennema and Peterson (1983) have suggested that it is difficult to understand how perceived usefulness affects achievement because achievement is affected by the student's locus of control. For example, if students believed that mathematics was useful but thought that it was beyond their control to be able to learn mathematics, their achievement might be lower than those students who had internal loci of control.

In an expectancy-value motivational framework, it is clear how mathematics self-efficacy and mathematics anxiety can influence a student's motivation to learn mathematics. Students with higher levels of mathematics self-efficacy are typically more motivated than their peers to work hard in mathematics because they believe they have the ability to succeed. Also, students with higher levels of mathematics anxiety are often less likely than their peers to be motivated in their mathematics classes because of their negative beliefs about the subject or their lack of ability. Using an expectancy-value motivational framework for this study allowed me to consider the students’ perspectives about their abilities and the mathematical tasks when developing and analyzing the questionnaire regarding students’ mathematics self-efficacy and mathematics anxiety.

Chapter 3

METHODOLOGY

The present study had both quantitative and qualitative components. The development process for the questionnaire involved item construction, reliability analysis, and establishing the construct validity of mathematics self-efficacy and mathematics anxiety items through exploratory factor analysis. Instructor comments and student interviews were used to improve items and interpret the results of the factor analysis.

Questionnaire Development

The purpose of this study was to develop a questionnaire that explores the relationship between college students' mathematics self-efficacy and mathematics anxiety. A questionnaire was initially developed with items addressing students' perceptions of their self-efficacy in mathematics and their feelings of anxiety toward mathematics with respect to various aspects of learning mathematics in college. The majority of the items for the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) came from a pilot version (see Appendix A), which was developed to provide college mathematics instructors and mathematics education researchers with information about students' self-efficacy in their ability to learn mathematics (May & Glynn, 2008). For the pilot version, a large pool of items was generated that addressed both the mathematics self-efficacy and mathematics anxiety of college students. These items were based on the research literature, and some of them were adapted from previous questionnaires designed to measure mathematics self-efficacy (Betz & Hackett, 1983), mathematics anxiety (Richardson & Suinn, 1972), and science self-efficacy and science anxiety (Glynn, Taasoobshirazi, & Brickman, 2007). The items chosen for the final version of the MSEAQ also took into account college mathematics instructors' input regarding their experiences with college students' self-efficacy and anxiety.

The items chosen for the final version of the MSEAQ were based on (1) feedback received when presenting pilot data at the Research in Undergraduate Mathematics Education (RUME) annual conference and (2) student interviews conducted during the pilot administration. First, an item that addressed students' anxieties about giving incorrect answers in a mathematics class was added: "I am afraid to give an incorrect answer during my mathematics class." Instructors that attended the session at RUME commented that students do not seem nervous about talking in class unless they are expected to give an answer. They suggested examining how students' fear of being wrong affects their classroom behavior. Another change made to the pilot version involved rewording items that include the word *anxious* as several students in the pilot interviews reported misunderstanding the word as used in the questionnaire. The final version of the MSEAQ is in Appendix B.

Participants and the Precalculus Course

This study was conducted with three groups of students: 61 students took an online version of the questionnaire, 109 students took a paper version of the questionnaire, and 13 students were interviewed while filling out a paper version of the questionnaire. All of the students were taking a precalculus course at the University of Georgia and no student participated in more than one group. The sections of precalculus chosen for this study were determined by the instructor's willingness to participate, and the participants were also selected on a volunteer basis consistent with the university policies for research with students. Precalculus was chosen for this study because that course is typically offered at most colleges and is usually taken by a wide range of students. The precalculus course at this university is typically taken by about 1200 students each semester and is often taught by at least 20 different instructors. Most of the students are freshmen, but some wait until their junior or senior year to take the course. Students are placed in the course based on their scores on either the university's mathematics placement exam score or on the mathematics section of a college entrance examination. Students are evaluated based on their performance on online homework assignments, in-class quizzes, unit exams, and a final exam. Homework assignments are made available through the course website and must be submitted through the online program. Students typically have one week to complete homework assignments. Instructors are not allowed to offer any kind of extra credit at any point in the semester.

In order to efficiently administer exams to the large number of students and to ensure consistency among exams, all students enrolled in the course, regardless of section, complete the same exam within a few days of each other via computer. During the exam, once students submit an answer, they are notified if they answered correctly. If not, they are given one more opportunity to submit an answer, which, if correct, will earn them 75% credit for that problem. Students have the option of submitting their answers as they work the problems or waiting to submit all of their answers at once. Students also have the option of having the time remaining displayed on the screen while taking the exam. All unit exams and the comprehensive final exam are given on the computer in this format.

Assessment Procedures

The MSEAQ was administered in three rounds; each round consisted of surveying a different group of students. In the first round, the MSEAQ was administered online to 61 participants in the precalculus course. In addition to the MSEAQ, the tasks subscale of the Mathematics Self-Efficacy Scale (Betz & Hackett, 1983) and the short version of the

Mathematics Anxiety Rating Scale (Suinn & Winston, 2003) were administered to assess concurrent validity. This administration was done to measure the agreement between the MSEAQ and existing measures, which are somewhat similar. Correlations were calculated to determine the concurrent validity of the MSEAQ items with respect to these previously established scales.

In the second round, the MSEAQ was administered in paper and pencil form to a separate group of 109 undergraduate students enrolled in the precalculus course. A paper and pencil form was used so the MSEAQ could be administered in class, which resulted in a greater number of students volunteering to participate. Because administration in class restricted the total time for administration, the Mathematics Self-Efficacy Scale and the Mathematics Anxiety Rating Scale items were not administered, but the number of students (n = 61) who responded to these items in the first round was sufficient for concurrent-validity analysis.

When students responded to the MSEAQ, they first responded to a set of background questions. To explore how high school preparation relates to students' mathematics self-efficacy, students were asked how many mathematics courses they took in high school, along with the highest mathematics class they took and the grades they typically received in their high school mathematics courses. Previous mathematics experience was taken into account by asking students their score on their most recent precalculus exam. To gauge students' mathematical background, they were also asked to report their Scholastic Assessment Test (SAT) mathematics exam score and their college mathematics placement exam score.

Interviews

In the third round, to understand how students interpret the items on the MSEAQ, a group of 13 undergraduate precalculus students were administered the MSEAQ in an interview format.

These 13 participants had not seen the MSEAQ prior to the interviews. The interviews were conducted using an interview guide based on the MSEAQ: the students were asked to respond to each of the items on the MSEAQ while explaining their responses. The interview-guide approach allowed me to feel free "to build a conversation within a particular subject area, to word questions spontaneously, and to establish a conversational style but with the focus on a particular subject that has been predetermined" (Patton, 2002, p. 343). Therefore, I was able to pursue topics as needed while still covering all of the necessary information with each participant. The interview guide included follow-up questions such as, "Why did you respond to that item that way?" and "What from your college mathematics experiences makes you feel that way?" Students were also encouraged to give examples supporting their decisions and to express any confusion regarding the items' meanings. The participants' responses were then grouped by item and analyzed for common themes with respect to each factor found in the exploratory factor analysis.

Chapter 4

RESULTS

In this section, the quantitative and qualitative results of this study are reported. First, to establish convergent validity, the first round of 61 students' responses to the items of the MSEAQ are compared with their responses to previously established mathematics self-efficacy and mathematics anxiety scales. Second, the reliability of the 61 students' responses to the MSEAQ was analyzed by examining the internal consistency of the instrument. Third, to provide evidence of construct validity, an exploratory factor analysis was conducted on the second round of 109 students' responses to the MSEAQ items. The exploratory factor analysis included the steps of factor extraction, rotation, retention, and interpretation, all of which are described. Fourth, to facilitate the interpretation of the factor analysis, the responses from the third round of 13 student interviews are reported. And fifth, the results of *t* tests are reported which compare how the second round of 109 students' factor scores differ by gender, high school mathematics experience, and college mathematics experience.

It is important to note that one of the items was not functioning as expected. The item "I believe I can think like a mathematician" seemed to be misinterpreted by students, based on students' responses in the interviews. The misinterpretation of the item is discussed with the interview results, but all of the analyses were conducted on the remaining 28 items on the MSEAQ, with the previously mentioned item removed.

Scale Verification

Table 1 reports the 61 students' total mean score, standard deviation, possible score range, and Cronbach's alpha for the MSEAQ, the 13-item self-efficacy scale of the MSEAQ, and the 15-item anxiety scale of the MSEAQ. Note that the anxiety items on the MSEAQ are reverse scored. Table 1 also includes these indices for the two established measures of mathematics self-efficacy and anxiety used to establish convergent validity: the 18-item mathematics-tasks subscale of the Mathematics Self-Efficacy Scale (MSES; Betz & Hackett, 1983) and the 30-item short version of the Mathematics Anxiety Rating Scale (s-MARS; Suinn & Winston, 2003). For the entire 28-item MSEAQ, the obtained Cronbach's coefficient alpha of .96, which measured the internal consistency of the MSEAQ, was considered to be very good. Therefore, the MSEAQ is considered to be highly reliable in terms of its internal consistency.

Table 1

Mean, Standard Deviation, Score Range, and Cronbach's Alpha for Five Scales

	Mean	SD	Possible score range	Cronbach's alpha
MSEAQ-SE	44.11	10.78	13-65	.93
MSEAQ-A	46.47	12.61	15-75	.93
MSEAQ-Total	90.58	22.78	28-140	.96
MSES	64.96	11.79	18-90	.92
s-MARS	106.49	16.51	30-150	.93

Note. For the MSEAQ, SE is the self-efficacy scale and A is the anxiety scale.

In order to verify that the MSEAQ was related to other, established measures of mathematics self-efficacy and anxiety, students' total scores on the mathematics self-efficacy scale of the MSEAQ were correlated with total scores on the mathematics-tasks subscale of the Mathematics Self-Efficacy Scale (MSES; Betz & Hackett, 1983), and students' total scores on the mathematics anxiety items on the MSEAQ were correlated with the items on the short version of the Mathematics Anxiety Rating Scale (s-MARS; Suinn & Winston, 2003). Note that the items on the s-MARS were reverse scored. These correlations are reported in Table 2. As expected, both correlations were statistically significant, but moderate, which is desirable in that the MSEAQ was developed to assess mathematics self-efficacy and anxiety somewhat differently than these constructs had been assessed in the past, consistent with the current theoretical views of Bandura (1997). Also, the MSEAQ self-efficacy and anxiety scales had a high correlation, as was expected; the correlation was positive because the anxiety-scale items were reverse scored.

Table 2

Correlations among Five Scales

	MSEAQ-SE	MSEAQ-A	MSEAQ-Total	MSES	s-MARS
MSEAQ-SE	1				
MSEAQ-A	.912**	1			
MSEAQ-Total	.975**	.981**	1		
MSES	.355*	.324*	.348*	1	
s-MARS	504**	.582**	.560**	.691**	1

Note. For the MSEAQ, SE is the self-efficacy scale and A is the anxiety scale. * is $p < .05$, and ** is $p < .01$.

Because the MSEAQ, the MSES, and the s-MARS were based on somewhat different views of mathematics self-efficacy and anxiety, the items which comprised these measures also varied, with some similarities and dissimilarities. For that reason, correlations between the items of the different measures were calculated to determine how they were related to each other. These correlations are reported in Table 13 in Appendix C; each mathematics self-efficacy item on the MSEAQ was significantly correlated with at least one item on the mathematics tasks subscale of the MSES. Similarly, correlations were calculated for the mathematics anxiety items on the MSEAQ with the items on the short version of the Mathematics Anxiety Rating Scale (s-MARS; Suinn & Winston, 2003). The correlations are reported in Table 14 in Appendix C; again each mathematics anxiety item on the MSEAQ had a significant correlation with at least one of the items on the s-MARS. Although the correlations for both the mathematics self-efficacy items and the mathematics anxiety items were statistically significant, they were not very high, but that is desirable. Not every item on the previously established scales correlated with an item on the MSEAQ. This was expected because the MSEAQ was not designed to imitate these scales. If the correlations were high, then the MSEAQ would be a redundant measure of mathematics self-efficacy and anxiety, not improving upon preexisting measures. Because the correlations were significant, but not high, the MSEAQ holds promise of having high validity, without duplicating previous scales.

For the entire MSEAQ, the obtained Cronbach's coefficient alpha of .94, which measured the internal consistency of the MSEAQ, was considered to be very good. Also, Cronbach's coefficient alphas were calculated for the mathematics self-efficacy and mathematics anxiety subscales, which were .90 and .91, respectively. Therefore, the MSEAQ is highly reliable in terms of its internal consistency.

Exploratory Factor Analysis

A paper version of the MSEAQ was administered to 109 precalculus students. To understand how students typically responded to these items, the mean and standard deviation of students' responses are given for each item in Table 3. Each item is measured on scale of 1 to 5 and the anxiety items are reverse scored. Two items had particularly high averages: "I get nervous when I have to use mathematics outside of school" and "I believe I can complete all of the assignments in a mathematics course." This suggests that, on average, students were not concerned about using mathematics outside of class and they felt confident about completing assignments. These results are confirmed in the discussion of the interview responses.

Table 3
Mean and Standard Deviation for MSEAQ Items

MSEAQ Item	Mean	Std Dev.
1. I feel confident enough to ask questions in my mathematics class.	3.489	1.236
2. I get tense when I prepare for a mathematics test.	2.409	1.335
3. I get nervous when I have to use mathematics outside of school.	4.178	0.960
4. I believe I can do well on a mathematics test.	3.667	1.066
5. I worry that I will not be able to use mathematics in my future career when needed.	3.911	0.996
6. I worry that I will not be able to get a good grade in my mathematics course.	2.600	1.214
7. I believe I can complete all of the assignments in a mathematics course.	4.091	0.960
8. I worry that I will not be able to do well on mathematics tests.	2.432	1.169
9. I believe I am the kind of person who is good at mathematics.	2.955	1.200
10. I believe I will be able to use mathematics in my future career when needed.	3.467	1.057
11. I feel stressed when listening to mathematics instructors in class.	3.727	0.997
12. I believe I can understand the content in a mathematics course.	3.795	0.978
13. I believe I can get an “A” when I am in a mathematics course.	3.111	1.265
14. I get nervous when asking questions in class.	3.689	1.221
15. Working on mathematics homework is stressful for me.	2.889	1.153
16. I believe I can learn well in a mathematics course.	3.400	0.986
17. I worry that I do not know enough mathematics to do well in future mathematics courses.	3.182	1.352
18. I worry that I will not be able to complete every assignment in a mathematics course.	3.778	0.997
19. I feel confident when taking a mathematics test.	2.689	1.104
20. I believe I am the type of person who can do mathematics.	3.333	1.225
21. I feel that I will be able to do well in future mathematics courses.	3.200	1.010
22. I worry I will not be able to understand the mathematics.	3.178	1.007
23. I believe I can do the mathematics in a mathematics course.	3.578	0.988
24. I worry that I will not be able to get an “A” in my mathematics course.	2.422	1.196
25. I worry that I will not be able to learn well in my mathematics course.	3.295	0.954
26. I get nervous when taking a mathematics test.	2.364	1.348
27. I am afraid to give an incorrect answer during my mathematics class.	2.659	1.293
29. I feel confident when using mathematics outside of school.	2.273	0.997

Note. Anxiety items are reverse scored.

In an exploratory factor analysis, there are multiple decisions that need to be made regarding how to carry out the analysis appropriately. First, the factors can be extracted using either principal components analysis or principal axis factoring. The goal of principal components analysis is data reduction; the analysis identifies which variables belong to which components, and then the components are used for further analysis. Principal axis factoring is primarily used to identify the number and characteristics of latent variables. For this study, the factors were extracted using principal axis factoring because the purpose of this study was to explore the underlying constructs of mathematics self-efficacy and mathematics anxiety in college students. Although some of the questionnaire items might be altered based on the results of this analysis, the purpose here is not data reduction and, therefore, a principal components analysis is not appropriate. The communalities, both before and after extraction, for the exploratory factor analysis are given in Table 4. The moderately high communalities indicate that the model does a good job accounting for the variation of the items.

Perhaps the most important decision in exploratory factor analysis is how many factors to retain. The goal is to retain only the factors that account for nontrivial variance; determining which variances are trivial is somewhat subjective. Although researchers do not agree on any single method being the most effective for factor retention, it has been suggested that multiple methods be used to determine the number of factors (Zwick & Velicer, 1986). For this study, a scree plot and parallel analysis were used for factor retention. A scree plot, which plots the eigenvalues in descending order, is typically used to get a rough estimate of the number of factors. Using the scree plot as a guide, all factors with eigenvalues in the sharpest descent of the graph are retained. The scree plot for this study, shown in Figure 1, suggests that five factors should be retained because the plot starts to level off with the sixth factor.

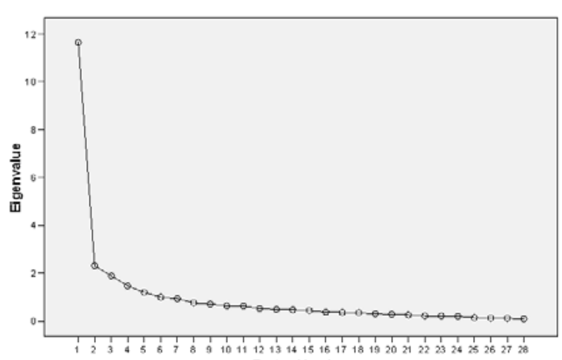

Figure 1. Scree Plot of Eigenvalues.

Table 4

Communalities for EFA

	Initial	Extraction
I feel confident enough to ask questions in my mathematics class.	.611	.850
I get tense when I prepare for a mathematics test.	.771	.668
I get nervous when I have to use mathematics outside of school.	.589	.491
I believe I can do well on a mathematics test.	.666	.630
I worry that I will not be able to use mathematics in my future career when needed.	.508	.431
I worry that I will not be able to get a good grade in my mathematics course.	.828	.788
I believe I can complete all of the assignments in a mathematics course.	.428	.496
I worry that I will not be able to do well on mathematics tests.	.823	.813
I believe I am the kind of person who is good at mathematics.	.765	.735
I believe I will be able to use mathematics in my future career when needed.	.564	.415
I feel stressed when listening to mathematics instructors in class.	.639	.534
I believe I can understand the content in a mathematics course.	.561	.441
I believe I can get an “A” when I am in a mathematics course.	.810	.702
I get nervous when asking questions in class.	.656	.614
Working on mathematics homework is stressful for me.	.508	.485
I believe I can learn well in a mathematics course.	.619	.535
I worry that I do not know enough mathematics to do well in future mathematics courses.	.546	.461
I worry that I will not be able to complete every assignment in a mathematics course.	.514	.501
I feel confident when taking a mathematics test.	.704	.675
I believe I am the type of person who can do mathematics.	.797	.776
I feel that I will be able to do well in future mathematics courses.	.660	.588
I worry I will not be able to understand the mathematics.	.655	.555
I believe I can do the mathematics in a mathematics course.	.582	.572
I worry that I will not be able to get an “A” in my mathematics course.	.625	.532
I worry that I will not be able to learn well in my mathematics course.	.759	.685
I get nervous when taking a mathematics test.	.780	.696
I am afraid to give an incorrect answer during my mathematics class.	.431	.353
I feel confident when using mathematics outside of school.	.509	.440

The parallel analysis procedure for determining the number of factors generates a random set of data derived from the actual set of data. Eigenvalues are then calculated for the randomly generated data and compared with the eigenvalues for the actual data. In theory, if an eigenvalue for the actual data is higher than the eigenvalue for the random data, it is considered to be of interest, and that factor should be retained. The results of the parallel analysis suggest that five factors should be retained (see Table 5): the eigenvalues calculated from the random data drop below the eigenvalues calculated from the actual data after the fifth factor is extracted. Based on the results from the scree plot and the parallel analysis procedure, five factors were retained.

Table 5

Parallel Analysis Results

	Eigenvalues	
Root	Actual data	Random data
1	10.69	1.32
2	1.88	1.14
3	1.49	1.01
4	1.06	0.89
5	0.75	0.80
6	0.58	0.71

In order to interpret the results better, factor rotations are often conducted on the extracted factors. Factor rotation allows certain restrictions required for factor extraction to be relaxed once the factors have been chosen. There are two basic types of factor rotations: oblique and orthogonal. Using an orthogonal rotation would force the factors to be uncorrelated, but using an oblique rotation allows the factors to be correlated and will default to an orthogonal rotation if the factors are actually uncorrelated. For this study, an oblique rotation was employed because it is likely that the factors were correlated because of the strong relationship between self-efficacy and anxiety in mathematics. The promax rotation procedure, a type of oblique rotation, was used because it has consistently been shown to produce simple structures with good solutions (Benson & Nasser, 1998; Gorsuch, 1983). The pattern matrix can be found in Table 15 and the structure matrix can be found in Table 16, both in Appendix D.

Using the rotated factor solution, it is necessary to determine which items loaded onto which factors. Typically, the cutoff point for salient loadings is considered to be .3 or higher. Because of the nature of mathematics self-efficacy and mathematics anxiety, I chose a higher cutoff point of .4 to help eliminate items from loading onto more than one factor. With this cutoff point, the items' loadings and factors have been marked in Table 15. Only one item, "I believe I can get an 'A' when I am in a mathematics course," loaded onto two factors, and only one item, "I am afraid to give an incorrect answer during my mathematics class," did not load onto any factors; the possible explanations for these loadings are covered in the discussion of the results of the interviews.

Although guided by previous literature and findings, factor interpretation is somewhat subjective. Sometimes it is clear why certain items load onto certain factors, but at other times, more investigation is required. In this study, it is relatively clear how the items loaded onto the factors. Factor 1 is a self-efficacy factor, but not all of the self-efficacy items loaded onto this factor. As shown in Table 6, the items that load significantly onto this factor seem to refer to students' general self-efficacy towards mathematics. Factor 2 is a factor related to how students feel about graded assignments. The items' loadings for this factor can be found in Table 7. The items that loaded onto this factor dealt with both self-efficacy and anxiety related to tests, and

Table 6

Pattern Matrix for General Mathematics Self-Efficacy Factor

	Factor				
	General Math Self-efficacy	Grade Anxiety	Future	In-class	Assignment
I believe I am the kind of person who is good at mathematics.	.829*	.101	.053	-.049	-.182
I believe I am the type of person who can do mathematics.	.820*	.123	.066	-.026	-.157
I believe I can learn well in a mathematics course.	.725*	-.137	.138	-.064	.069
I feel that I will be able to do well in future mathematics courses.	.612*	.064	-.020	.057	.211
I believe I can understand the content in a mathematics course.	.541*	-.027	.018	.223	.090
I believe I can get an “A” when I am in a mathematics course.	.538*	.513*	-.138	-.021	-.098
I believe I can do the mathematics in a mathematics course.	.518*	-.063	.309	.045	.117

Note. * indicates significant loading onto factor.

Table 7

Pattern Matrix for Grade Anxiety Factor

	Factor				
	General Math Self-efficacy	Grade Anxiety	Future	In-class	Assignment
I worry that I will not be able to do well on mathematics tests.	.085	.850*	.014	-.109	.066
I get tense when I prepare for a mathematics test.	-.035	.825*	.086	-.045	-.038
I get nervous when taking a mathematics test.	.046	.798*	.032	.048	-.090
I worry that I will not be able to get an “A” in my mathematics course.	-.128	.725*	.154	.077	-.150
I worry that I will not be able to get a good grade in my mathematics course.	.260	.706*	-.056	-.184	.164
I feel confident when taking a mathematics test.	.278	.658*	-.132	.078	-.010
I believe I can do well on a mathematics test.	.383	.473*	-.207	.098	.174
Working on mathematics homework is stressful for me.	-.329	.417*	.253	.119	.313

Note. * indicates significant loading onto factor anxiety about grades and homework. The items' loadings for Factor 3 can be found in Table 8; Factor 3 relates to self-efficacy and anxiety with respect to future courses, careers, and experiences with mathematics.

Table 8

Pattern Matrix for Future Factor

	Factor				
	General Math Self-efficacy	Grade Anxiety	Future	In-class	Assignment
I get nervous when I have to use mathematics outside of school.	-.056	.099	.752*	-.098	-.107
I feel confident when using mathematics outside of school.	.179	-.121	.687*	-.037	-.121
I worry that I will not be able to use mathematics in my future career when needed.	-.105	.006	.615*	.015	.152
I worry I will not be able to understand the mathematics.	.273	.017	.573*	-.070	.027
I worry that I will not be able to learn well in my mathematics course.	.215	.152	.541*	.055	.040
I feel stressed when listening to mathematics instructors in class.	-.009	.116	.513*	.232	.031
I believe I will be able to use mathematics in my future career when needed.	.345	-.178	.477*	.157	-.093
I worry that I do not know enough mathematics to do well in future mathematics courses.	.106	.160	.437*	.018	.107

Note. * indicates significant loading onto factor.

The loadings for the items of Factor 4 and Factor 5 can be found in Table 9. Factor 4 deals with anxiety about asking questions in class; it is important to notice that if the salient loading value had been lower, then the item "I am afraid to give an incorrect answer during my mathematics class" would have loaded onto this factor as expected. But the item also would have loaded onto the Future factor, suggesting that students are not interpreting this item as intended. Based on the students' responses in the interviews, discussed in the next section, this factor perhaps was not being interpreted as expected. The item was left in the analysis, however, because it was deemed important by college mathematics instructors. Factor 5 has items about how students feel about their abilities or anxieties to complete assignments in a mathematics course.

Table 9

Pattern Matrix for In-Class Factor and Assignment Factor

	Factor				
	General Math Self-efficacy	Grade Anxiety	Future	In-class	Assignment
I am afraid to give an incorrect answer during my mathematics class.	-.172	.222	.336	.314	-.112
I feel confident enough to ask questions in my mathematics class.	.107	-.125	-.178	.987*	.147
I get nervous when asking questions in class.	-.030	.104	.234	.626*	-.095
I believe I can complete all of the assignments in a mathematics course.	-.001	-.026	-.106	.120	.736*
I worry that I will not be able to complete every assignment in a mathematics course.	.043	-.125	.451	-.233	.471*

Note. * indicates significant loading onto factor.

To get a better idea of how the items for each factor are related within their respective factors, the interview data are discussed, factor by factor.

Interviews

One of the initial purposes of the interviews was to establish that participants were interpreting the questionnaire items as intended. The main item that did not function as expected was “I believe I can think like a mathematician.” Several students interpreted the item as asking whether or not they were a mathematics-type person. For example, one student said, “I don’t think so. It’s more of…have you ever heard of the theory of left brain vs. right brain? Well, I’m more conceptual.” Other students felt that they could think like a mathematician if they wanted to but, for various reasons, they chose not to. These students were confused as to how they should respond to the item as evidenced by a student who said, “No…I just wouldn’t want to have to memorize that much. I mean, I understand things as we go, but they have to remember everything all at once." Thus, this item was dropped from the scale, as mentioned previously, because students did not seem to interpret this item consistently as saying that they believed they could approach problems or think about mathematics the way a mathematician would.

An additional purpose of the interviews was to verify that the factors from the exploratory factor analysis were being identified and interpreted correctly. Each factor is discussed below, along with typical student responses that support the interpretation of the factor.

General Mathematics Self-Efficacy factor. Factor 1 was identified as the General Mathematics Self-Efficacy factor, with items on this factor being related to the self-efficacy of students with respect to general mathematics abilities. When responding to these items, students typically reflected on personal characteristics and beliefs and how these characteristics and beliefs affected their self-efficacy in mathematics classes. The most common response was that they did not believe that they were the type of person who was good at mathematics, which influenced how they responded. This belief was seen in responses such as "Math has always been a weak subject for me. It's always been my lowest grade" and "Oh, no. I'm terrible at math. I'm awful. I'm better at memorizing stuff, even though this stuff kind of is memorizing, I'm just not a math person."

Students clearly conceptualized their self-efficacy in doing and understanding mathematics differently from their self-efficacy to complete tasks in their mathematics classes, such as tests and assignments. Students' conceptions of their general abilities in mathematics seemed to be independent of the current mathematics course they were taking but heavily influenced by their previous experiences in mathematics. As expected, students typically reflected on how their long-term experiences with mathematics influenced their views of their abilities, often saying they had never been good at mathematics or had never been the type of person who could do mathematics. Interestingly, students were never specific about the bad experiences they had had with mathematics; instead, they simply said that it had always been that way. Although it is often assumed that students have these beliefs because of poor mathematics achievement in their past, those interviewed did not typically discuss the specific experiences that caused them to believe they could not do mathematics.

Grade Anxiety factor. Factor 2 was identified as the Grade Anxiety factor and contained items related to the self-efficacy and anxiety of grades in their mathematics classes. Grouping together the self-efficacy and anxiety with respect to grades in mathematics classes was supported by the responses in the interviews. Students frequently commented that once their confidence in an exam diminished, their anxiety increased. For instance, one student noted, "I usually will be confident when I go in to take it. Usually the first or second [question] is kind of easy, but when I get to one where I have no idea, then I start to worry." Statements like this seemed to indicate that if a student did not have confidence about an exam or grade, she or he then had some level of anxiety.

The students perceived their self-efficacy and anxiety toward their grades in mathematics differently than their self-efficacy and anxiety about doing mathematics in general. The students felt strong pressure to maintain high grades throughout college for various reasons, ranging from obtaining their degree requirements to being eligible for future graduate programs. One of the more common reasons mentioned by students for their anxiety toward grades was to retain their eligibility for their academic scholarships. The type of state-funded scholarship that most students in the class had received required them to maintain a grade point average of 3.0 (on a

4.0 scale). This requirement placed additional stress on the students regarding the importance of their mathematics grades.

The students' grade anxiety was also influenced by their experiences in high school mathematics courses. Most students reported that they typically received A's in previous high school mathematics courses and were surprised that they were struggling with their grades in a college mathematics course. One student summarized her expectations by saying, "I got A's all through high school. I thought I was going to get an A…I had a precalculus teacher [in high school], and she used to talk about how all her students who went to UGA got A's in their math classes." Researchers have found that students often receive higher grades in their high school mathematics courses than their scores on standardized mathematics exams indicate because of grade-inflation pressures on instructors (Schmidt, 2007). This grade inflation in high school gives students the idea that it is easy to get good grades in mathematics courses. Also, the inflated grades at the high school level cause students to feel pressure to continue getting A's in college because they were always able to get good grades in high school.

One of the main consequences of mathematics anxiety related to grades that was apparent in the interviews was students' fear of taking mathematics tests. Test anxiety in general is a well documented phenomenon, but researchers believe that anxiety on mathematics tests is more detrimental than general test anxiety (Ashcraft & Ridley, 2005). Some students commented that, although they had performed well on previous exams, they were still worried about their grades because they still had to take the final exam. One student explained, "Even though I have an A average now, I have to get an 83 or 84 on the final to get an A. I should be able to do that because I haven't scored that low on any of the exams, but I'm still nervous." Students, therefore, felt a lot of pressure for each exam they took because each exam was crucial for their grade. The importance of each exam, then, is likely to increase students' levels of anxiety in their mathematics courses.

Future factor. Factor 3 was identified as the Future factor, with these items being related to self-efficacy and anxiety regarding future courses and careers. Interviewees' comments discussed how self-efficacy and anxiety seemed to overlap in this area. When responding to how confident she felt about using mathematics in her career, one student repeated what she had said when asked about her anxiety in this area. "Again, I think that maybe sometimes for now, but potentially with more classes, I'll be better. I'm not confident now, but I'm not worried because I believe I will get there." It seemed that many students had not given thought to their abilities to do mathematics in their future careers, but instead, they assumed that their coursework would prepare them for whatever they would need. Therefore, they did not necessarily feel confident or anxious about using mathematics in their careers because they had not considered what would be required in their careers.

The students tended to group together ideas about how confident or anxious they feel about working with mathematics in the future, whether it is future mathematics coursework or using mathematics in their future careers. Although some students expressed a lack of confidence in mathematics, they did not necessarily lack confidence about using mathematics in the future because they believed that their coursework would prepare them for whatever they would need to know. They did not appear to realize, however, that if they did not understand the required material in a course, then they might not be adequately prepared by that course for the future. Furthermore, several students reported that they did not believe they would need mathematics for their future careers; therefore, they were confident that they already knew all of the mathematics required for their careers. One way to help students realize the importance of understanding the mathematical content for their future careers could be to include more mathematical problems and tasks related to students' future careers in students' mathematics coursework. Although it would be difficult to include problems for each possible career, the inclusion of applications to various fields could help students make the connection between the classroom and the workplace.

Another interesting, although not surprising, outcome of the interviews was that most students had difficulty discussing how they use mathematics in their daily lives. Many claimed they did not use mathematics in their daily lives, whereas others assumed that referred to calculating tips and sales tax. These responses help clarify why the students viewed their self-efficacy and anxiety about the mathematics they used in their daily lives similarly to their self-efficacy and anxiety about the mathematics they would use in their careers: Most did not believe they would have to use much mathematics in either case.

In-Class factor. Factor 4 was labeled the In-Class factor, with items covering students' self-efficacy and anxiety related to asking questions in class. In the interviews, there were two typical responses about how they felt about asking questions in class. The first type of response, which was more common, was that asking questions was not a big deal because they were in school to learn. A typical response was "I don't get nervous. I mean, I'm there for my own learning." The second type of response came from students who did not ask questions in class. These students commented on how their mathematics self-efficacy and anxiety were not involved in their willingness to ask questions because they were just not comfortable speaking up in any class. This view is illustrated by a student who said, "No, I don't. But that's just me; I don't ask questions in any of my classes." These students did not see their lack of participation as evidence of lacking self-efficacy or having anxiety about asking questions because they just were not the type of person to ask questions in class.

Also, it should be noted that the item "I am afraid to give an incorrect answer during my mathematics class" almost reached the criterion for loading onto Factor 4. It seems that some students might have responded to this item differently from intended, pointing out that if they were afraid their answer was incorrect, they would not share it in front of the class. For example, one student explained, "Yeah, I usually make sure I know what I'm saying before I say it." Therefore, students typically responded that they were not anxious about giving an incorrect answer because their anxiety about being incorrect would keep them from giving an answer in the first place. This alternate interpretation of the item likely kept it from loading onto the factor that deals with asking questions in class.

Assignment factor. Factor 5 was identified as the Assignment factor, with items involving students' self-efficacy and anxiety related to completing assignments. A common theme for the students' responses to the items in this factor showed that they believed that if they gave themselves enough time, they could always complete their assignments. When asked if working on homework was stressful, most students repeated answers similar to the responses they gave regarding their confidence on homework, such as, "Like I said, it's not hard at all. If you don't get hundreds on your homework, then you just don't apply yourself. They give you so many opportunities…It's not that hard." Another issue regarding the lack of students' anxiety on the homework is that some students realized that the practice problems were formatted in such a way that they could plug in the numbers from their homework assignment and get the correct answer without knowing what they were doing:

> It doesn't stress me out. Usually, there's like a…am I allowed to tell you this? Well, normally, there's a little button that says 'Practice another

> problem' and if you look at the answer and how it's formatted, it's easier to figure out how to work it out if you don't know how. You can do it that way, but I do it to learn how to do the problems.

Another student commented on how he was doing very poorly on the tests but managed to get 100 percent on each homework assignment because "for the homework, I just cut and paste." The students seemed to feel that there were multiple resources, both intended and not, that would ensure that they could complete all of the assignments. Therefore, their confidence in completing assignments was related to their lack of anxiety because the provided resources seemed not only to provide them confidence in assignments but also to remove any anxiety about not finishing assigned work. Students' confidence or anxiety regarding assignments clearly depends on the structure and resources of the course, and the results I found for this course might not apply to other college mathematics courses.

The students reported that they typically were quite confident in completing assignments in their mathematics courses and that the only anxiety they felt about completing assignments occurred when they did not allow themselves enough time to complete the assignment. One student explained, "They always give plenty of time to get it done, usually like two weeks. I only get worried if I wait till the last minute." Time constraints in mathematics classes have been known to increase students' mathematics anxiety, although this increase is typically associated with timed tests (Walen & Williams, 2002). Several students reported that they believed instructors gave them more than enough time to complete assignments, indicating that if time constraints did cause anxiety, it was a result of the students procrastinating.

When provided with multiple resources in their mathematics class, the students felt completely confident that they would be able to complete all of the assignments required. When working on homework problems, the students could seek help from their instructor, fellow classmates, the textbook, or example problems online. The students frequently commented that it was easier to understand the mathematics during instruction, when the instructor was assisting. One student noted, “And it’s also different when you don’t see the teacher doing it on the board. It’s not as easy when you have to do it yourself.” The confidence the students had about completing assignments was related more to the confidence they had in the availability of resources, not in their mathematical abilities. When taking mathematics exams, students lost some of their confidence because they no longer had these resources available to them.

It is important to note that the students reported that they felt anxious when working on homework, but they were not typically concerned that they could not complete homework. This anxiety about working on the assignments was related to the students’ concerns about their grades, as discussed previously. Homework is often used as a way to help students get additional practice with the concepts they are learning in class; however, courses vary in how much homework affects students’ grades. This result is dependent on the structure of the course in the study and might not be found in other mathematics courses.

Students’ Background Variables

To explore how students’ backgrounds were related to their responses to this questionnaire, *t* tests were used to determine if student characteristics influenced how they responded to each of the five factors. The *t* tests were conducted with students’ regression factor scores on each of the five factors. Regression factor scores were used because the communalities were consistently larger across the set of items (Dobie, McFarland, & Long, 1986). Several background questions, however, were not used in the analysis. Most students could not remember what they scored on the mathematics section of the SAT; similarly, many either could not remember their college mathematics placement exam score or they did not take the placement exam. Also, most students had difficulty determining the highest mathematics course they took in high school; several students wrote more than one course title and some left the question blank. Thus, these background questions were not used in the analysis.

For all of the *t* tests, a significance level of .05 was used. The results of the *t* tests that compared male and female students' factor scores are given in Table 10. The results showed no significant difference in the factors of mathematics self-efficacy and anxiety between male and female students; this lack of significant difference is not surprising. Researchers have shown that when males and females have similar mathematics backgrounds, the difference between their levels of mathematics self-efficacy decreases significantly (Lent, Lopez, & Bieschke, 1991). The students in this precalculus class were all placed in the class based on their performance on the college placement exam or based on the recommendation of an academic advisor. Also, all of the students must have had similar standardized mathematics tests scores because they all were accepted to the same highly competitive university. Therefore, it is likely that these students had similar mathematics backgrounds and the difference between the males' and females' levels of mathematics self-efficacy had diminished.

Table 10

Results of t *test for Gender*

Factor	*t*	Significance
General Mathematics Self-Efficacy factor	0.920	.092
Grade Anxiety factor	-0.225	.822
Future factor	-0.148	.882
In-Class factor	0.923	.358
Assignment factor	0.410	.682

To examine the impact of the number of high school mathematics courses on students' responses, *t* tests were conducted, comparing the factor scores of students who had taken four or more mathematics courses in high school to students who had taken three or fewer high school mathematics courses. The results of these *t* tests, given in Table 11, also showed no significant differences regarding students' responses to the five factors. It is likely that although students took different numbers of mathematics courses in high school, they ultimately had similar mathematical preparation by the time they took this precalculus course.

Table 11

Results of t *test for High School Courses*

Factor	*t*	Significance
General Mathematics Self-Efficacy Factor	-0.404	.687
Grade Anxiety Factor	-0.098	.922
Future Factor	-1.122	.264
In-Class Factor	0.241	.810
Assignment Factor	-1.484	.141

To explore how previous college mathematics experiences affected the students' responses on the MSEAQ, *t* tests were conducted that compared the factor scores of students who had passed their most recent precalculus exam to students who had failed their most recent precalculus exam. The results of these *t* tests are given in Table 12. A significant difference was found on the General Mathematics Self-Efficacy factor, demonstrating that previous experiences do affect how the students responded to the general mathematics self-efficacy items. These results confirm previous research on how successful mastery experiences, or the lack thereof, can contribute to, or take away, from students' self-efficacy in mathematics (Usher & Pajares, 2009; Zeldin, Britner, & Pajares, 2008). Research has shown that previous experiences in mathematics have a great impact on students' mathematics self-efficacy. When the students with low self-efficacy discussed their mathematics self-efficacy, they often commented that they did not do well in mathematics courses or got bad grades on mathematics tests. These responses support the conclusion that the students' previous precalculus exam scores had an effect on their general mathematics self-efficacy.

Table 12

Results of t *test for Precalculus exam*

Factor	*t*	Significance
General Mathematics Self-Efficacy factor	3.489*	.001
Grade Anxiety factor	0.925	.357
Future factor	1.183	.240
In-Class factor	1.279	.204
Assignment factor	1.262	.210

Note. * is $p < .05$.

Chapter 5

DISCUSSION

A questionnaire was designed in this study to explore how college students conceptualize their mathematics self-efficacy and mathematics anxiety. Although this questionnaire, the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ), still needs further development, it can help mathematics educators and researchers understand more about students who lack self-efficacy in certain areas of their mathematics studies or who have anxiety toward learning and using mathematics. The MSEAQ is based on a general expectancy-value model, which is highly applicable to exploring students' mathematics self-efficacy and anxiety. Items for this questionnaire were adapted from previous mathematics self-efficacy and mathematics anxiety scales and were verified using correlation analysis with these previous scales.

Participants for this study included three different groups of undergraduates enrolled in a precalculus course at the University of Georgia. The students were placed into this course based on their scores on the university's mathematics placement exam or on the mathematics portion of the SAT or ACT. In this course, the students were expected to complete online homework assignments and take chapter exams and a final exam on the computer. They were provided with practice problems and exams, both available online. The first group in this study consisted of 61 students, who completed online versions of the MSEAQ, along with the mathematics tasks subscale of the Mathematics Self-Efficacy Scale and the shortened version of the Mathematics Anxiety Rating Scale. The results of these students' responses were used to establish the reliability and validity of the MSEAQ. The second group of 109 students completed paper versions of the MSEAQ in class during the last week of class. The third group of 13 students from the course were interviewed while they responded to the items on the MSEAQ.

Exploratory factor analysis was used to examine the dimensions along which the students conceptualized their mathematics self-efficacy and mathematics anxiety. Using principal axis factoring and a promax rotation, items from the MSEAQ loaded onto five factors: General Mathematics Self-Efficacy, Grade Anxiety, Future, In-Class, and Assignments. The interpretation of these five factors was verified through the participants' responses during the interviews.

The General Mathematics Self-Efficacy factor included items about the students' beliefs regarding their abilities in mathematics in general. For example, items like "I believe I am the kind of person who is good at mathematics" and "I believe I can understand the content in a mathematics course" loaded onto the general mathematics self-efficacy factor. In the interviews, the students typically reflected about their overall experiences in mathematics in the past, without referencing specific previous experiences that affected their beliefs and attitudes. This factor seemed to relate to how the students felt in general about their mathematical abilities, based on a long-term view of their experiences in mathematics.

The Grade Anxiety factor reflected the students' concerns about their grades on assignments, on exams, and in the mathematics course overall. The students' confidence about their mathematics grades was related to their anxiety toward grades, with the interviewed students reporting that once they started to lose confidence about their grades, they immediately started to become worried. In the interviews, the students commented on how grades could have a long-term impact on their future, including scholarship and college program eligibility. Although anxiety about grades is not necessarily specific to mathematics, the students' specific anxiety towards mathematics exams seemed to enhance their anxiety about their mathematics grades.

The Future factor involved items about the students' confidence and anxiety about using mathematics in their future careers, along with their anxiety about using mathematics in future courses. Most of the interviewed students reported that although they did not feel confident about using mathematics in their future careers and courses, they were not worried because they believed that their coursework would prepare them for whatever mathematics they might need. The students also were typically neither anxious nor confident about using mathematics outside of school because they did not believe that they needed mathematics in their everyday lives; in the interviews, most of the students could not think of instances when they used mathematics outside of school.

Items that loaded onto the In-Class factor involved the students' concerns and confidence about asking questions in class. The students' responses in the interviews indicated that this factor might be related to the students' personalities, but some of the students indicated that speaking up in mathematics classes made them more nervous than in other classes. This factor was considered to be relatively weak because it contained two items. Also, an item regarding the students' anxiety about giving incorrect answers almost loaded onto this factor, indicating that this factor is most likely related to the students' confidence and anxiety about speaking up in mathematics classes.

The Assignment factor involved items about the students' mathematics self-efficacy and mathematics anxiety regarding completing assignments for their mathematics course. Unexpectedly, items about completing assignments in mathematics courses were not related to the students' self-efficacy or anxiety about grades in their mathematics courses. This result is likely due to the fact that most of the students reported feeling confident about completing their mathematics assignments and therefore did not expect the assignments to negatively affect their grades. This factor was also considered to be weak because it only retained two items.

Regression factor scores for the five established factors were used to compare the students' responses based on various student background characteristics. No significant differences in factor scores were found based on the students' gender or number of high school mathematics courses. This confirms previous research that students with similar mathematical backgrounds report similar levels of mathematics self-efficacy and anxiety (Lent, Lopez, & Bieschke, 1991). Although some of the students took more mathematics courses in high school than the other students, they all had similar mathematics preparation considering that they were placed into the same precalculus course. A significant difference was found for factor scores on the General Mathematics Self-Efficacy factor based on the students' most recent precalculus exam score. This result confirms Bandura's (1997) findings that mastery experiences greatly affect students' levels of mathematics self-efficacy.

Conclusions

The questionnaire developed in this study is a reliable, relatively valid instrument that can be used to explore the multiple dimensions of college students' mathematics self-efficacy and mathematics anxiety. At the same time, the questionnaire should be revised and improved in future studies to increase its validity, particularly its construct validity. In the process of questionnaire development, "construct validity is a never-ending, ongoing, complex process that is determined over a series of studies in a number of different ways" (Pett, Lackey, & Sullivan, (2003, p. 239). Furthermore, researchers can reliably and validly administer the MSEAQ online or in person. The online format enables researchers to collect data on a large number of students and decreases the error involved with data entry. College mathematics instructors can administer this survey online to large lecture courses, without using resources like class time.

As the results of this study have confirmed, mathematics self-efficacy and mathematics anxiety are complex constructs, with multiple dimensions. Although I initially expected students to conceptualize their mathematics self-efficacy and mathematics anxiety separately, the results of this study suggest that students actually view their mathematics self-efficacy and their mathematics anxiety similarly along five dimensions. Therefore, when designing a questionnaire to explore students' mathematics self-efficacy and mathematics anxiety, researchers need to include items that cover a variety of factors that address both constructs. College students do not simply have high or low levels of mathematics self-efficacy; instead, there are areas of mathematics that they might feel confident about, while they lack confidence in other areas. A student might feel quite confident about understanding the material or completing the homework, but still might lack confidence about succeeding on mathematics exams. It is important that researchers consider the various aspects involved with mathematics self-efficacy and mathematics anxiety before designing a questionnaire to explore these constructs.

Researchers also need to consider what previous experiences students might have had in mathematics when designing a mathematics self-efficacy and anxiety questionnaire. The results of this study showed that the students' recent precalculus experiences affected how they responded to the general mathematics self-efficacy factor items. Researchers have shown that mastery experiences affect students' mathematics self-efficacy and anxiety, and therefore it is important to be familiar with the general background of the students taking the questionnaire. For example, if the course is remedial, it is likely that many of the students will lack successful mastery experiences, which will affect how they respond to the questionnaire.

The results of this study showed that the students often conceptualized their mathematics self-efficacy and mathematics anxiety along similar dimensions. For example, when reflecting on their anxiety towards taking mathematics exams, the students often associated their anxiety with their lack of confidence in taking exams. When designing instruments that explore these constructs, it is important to include items on both mathematics self-efficacy and mathematics anxiety for each area to get a better understanding of students' conceptions and beliefs.

Implications

The results of this study have multiple implications for the assessment of college students' mathematics self-efficacy and mathematics anxiety. Some of these implications relate to course structure, and others relate to computerized assessment of learning.

Course structure. When exploring students' self-efficacy and anxiety regarding their college mathematics courses, it is important to consider how the course is structured, including how students are assessed and the resources available to the students. It is likely that students will feel more or less anxious about certain aspects of their mathematics courses, depending on how those aspects affect their grades. For example, the students in the present study typically seemed anxious about every exam in their mathematics course because the results would have a significant impact on their grade. The students were not, however, very anxious about their homework assignments because they believed they would always be able to get a good grade on the assignments. Furthermore, the students were not very anxious about their assignments, because they believed that they were provided with sufficient resources to complete all of the assignments. The students' mathematics self-efficacy and mathematics anxiety can be influenced by how the course is organized, and it is important for instruments exploring these constructs to take into account the structure of the students' current mathematics courses in order to cover all of the important areas where the students might feel anxious.

Computerized assessment. Researchers need to consider how the assessment is administered in mathematics courses when designing mathematics self-efficacy or mathematics anxiety instruments. When the students discussed in interviews their anxiety regarding their mathematics exams, most commented on their dislike of taking the tests on a computer, which was a requirement in the precalculus course.

> I definitely get nervous because it's on the computer because you know when you click that button, even though I know that it's going to be right, I second guess myself so much. I don't want to click that button and see that it's wrong. There's no way to double-check your answer.

Researchers have found that students with higher levels of mathematics anxiety are likely to perform better on paper-and-pencil tests than on computerized tests (Ashcraft, 2002). Although the exact reason for the difference between performances on computerized and paper tests is not fully understood, a number of explanations have been given as to why students might not perform as well on computerized tests: These explanations involve computer anxiety, familiarity with computers, screen size and resolution, test flexibility, and cognitive processing (Leeson, 2006).

Another possible reason for a performance difference on computer and paper mathematics tests is that students usually cannot receive partial credit for any correct mathematical work they have done when using a computer; instead, all of the emphasis is placed on whether or not the answer is correct. The students commented on how this feature made them anxious about taking the tests online, with one student explaining "Especially since the tests are online, because I'm used to…if I miss a negative, well the teacher will see that I had everything else right and I'll get partial credit." The lack of partial credit on the exams put pressure on the students, emphasizing that they could not make any trivial mathematical errors such as entering numbers into a calculator incorrectly or forgetting a negative sign.

The formatting and presentation of the exams on the computer also might have influenced the anxiety the students felt toward the exams. Many of the students commented that immediate responses from the computer decreased their confidence during the exam. One student expressed this by saying, “The thing I don’t like is that it tells you right then if you got it right. That can be nice when you were right, but it’s really stressful if you got it wrong.” Each question that the students answered incorrectly would increase the pressure they felt on the remaining questions. Also, based on the students’ responses in this study, many would have benefited from the removal of a timer display during the exam. These aspects of the assessment in the mathematics course should be taken into consideration when exploring mathematics self-efficacy and mathematics anxiety

Future Research

The questionnaire developed in this study can be used as a starting point for future research studies on the mathematics self-efficacy and mathematics anxiety of college students. There are at least three areas of research that merit attention: The relationship between mathematics self-efficacy and anxiety, the role of students’ previous mathematics experiences on their self-efficacy and anxiety, and the effectiveness of intervention techniques on mathematics self-efficacy and anxiety.

Relationship between mathematics self-efficacy and math anxiety. The results of this study found factors indicative of how students conceptualize their mathematics self-efficacy and mathematics anxiety. To gain a better understanding of these factors and the relationship between mathematics self-efficacy and mathematics anxiety, researchers need to develop more items that target the five factors found in this study. Specifically, more items need to be developed that address the In-Class factor and the Assignment factor to strengthen these two factors, which were relatively weak with only two items loading onto each factor. For example, items such as “I get nervous when going to my instructor’s office hours” and “I feel confident enough to seek help outside of class” could be added to the MSEAQ to examine further students’ confidence and anxiety towards asking questions in their mathematics classes.

Furthermore, researchers need to investigate how the relationship between mathematics self-efficacy and mathematics anxiety affects instructors’ attempts to increase college students’ mathematics self-efficacy and to decrease their mathematics anxiety. For example, suppose a student has a low level of mathematics anxiety, but still is not very confident about his or her abilities in mathematics in general. If an instructor implements techniques to alleviate students’ mathematics anxiety, these techniques might not help build this particular student’s mathematics self-efficacy. Once the relationship between students’ mathematics self-efficacy and mathematics anxiety is better understood, researchers can make recommendations about how instructors can effectively approach both increasing students’ mathematics self-efficacy and decreasing mathematics anxiety.

Previous experiences. Because of the important influence of students’ previous experiences in mathematics on their mathematics self-efficacy and mathematics anxiety, researchers need to have a better understanding of the types of previous experiences that can influence students’ mathematics self-efficacy and mathematics anxiety. Conducting thorough interviews with high school or college students with lower levels of mathematics self-efficacy or higher levels of mathematics anxiety could help bring to light ways that teachers can build positive mathematics attitudes in students. Also, interviewing students might reveal specific classroom experiences that have contributed to lower mathematics self-efficacy and higher mathematics anxiety. Previously, researchers have conducted case studies to examine students' experiences in mathematics (Taylor & Galligan, 2006; Walen & Williams, 2002); however, a larger sample of students needs to be thoroughly interviewed in order to reveal patterns in classroom experiences that lead to lower levels of mathematics self-efficacy and higher levels of mathematics anxiety.

Intervention techniques. The MSEAQ can also be used to help evaluate the effectiveness of various intervention techniques. Although researchers have suggested multiple techniques to help students, little research has been conducted to validate these techniques and demonstrate how they can be implemented successfully. For example, researchers have suggested that providing students with positive mastery experiences in their college mathematics courses will increase the students' mathematics self-efficacy (Bandura, 1997; Usher & Pajares, 2009; Zeldin, Britner, & Pajares, 2008); however, little research has been conducted to show how college mathematics instructors can effectively provide positive mastery experiences in order to successfully raise their students' mathematics self-efficacy. By studying and validating intervention techniques, researchers can provide instructors with effective methods to increase students' learning and achievement in college mathematics courses.

Summary

College students' mathematics achievements and performances are often influenced by their mathematics self-efficacy and mathematics anxiety. In this study, a reliable, relatively valid, and efficient questionnaire, the MSEAQ, was developed to assess college students' mathematics self-efficacy and mathematics anxiety and examine how these constructs are related to each other. This questionnaire provides researchers and instructors with a tool to assess and understand students’ self-efficacy and anxiety. This understanding can lead, ultimately, to improvements in students mathematics achievement. The results of this study provide a foundation for future studies designed to improve the validity of the MSEAQ and extend researchers’ understanding of the relationship between mathematics self-efficacy and anxiety. The MSEAQ will benefit researchers who wish to explore relationships among college students’ mathematics self-efficacy, mathematics anxiety, other student characteristics, and criterion variables such as mathematics achievement. The questionnaire will also benefit instructors who wish to better assess and understand their students’ mathematics self-efficacy and anxiety in order to increase their students’ achievement.

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Appendix A - Pilot Version of the MSEAQ

In order to better understand what you think and feel about your college mathematics courses, please respond to each of the following statements on a scale of 1 (Never) to 5 (Usually).

1. I have been able to understand mathematics.
2. I have done well in my mathematics courses.
3. I have enjoyed mathematics.
4. I am the type of person who is able to learn mathematics well.
5. I have been happy in my mathematics courses.
6. Mathematics instructors have been willing to help me learn the material.
7. I have asked questions in my mathematics classes.
8. I have sought help from mathematics instructors outside of class.
9. I have set goals in my mathematics classes.
10. I have worked with other students in my mathematics classes.
11. I have worked hard in my mathematics classes.
12. I regularly do assigned homework in my mathematics classes.
13. Working on mathematics homework is stressful for me.
14. I worry I will not be able to understand the mathematics.
15. I get nervous when asking questions in class.
16. I get tense when I prepare for a mathematics test.
17. I believe I can do the mathematics in a mathematics course.
18. I believe I am the kind of person who is good at mathematics.
19. I worry that I will not be able to do well on mathematics tests.
20. I worry that I do not know enough mathematics to do well in future mathematics courses.

21. I believe I can get an “A” when I am in a mathematics course.

22. I worry that I will not be able to get a good grade in mathematics courses.

23. I believe I can learn well in a mathematics course.

24. I believe I can think like a mathematician.

25. I believe I can complete all of the assignments in a mathematics course.

26. I get nervous when I have to use mathematics outside of school.

27. I believe I can understand the content in a mathematics course.

28. I believe I can do well on a mathematics test.

29. I am anxious when mathematics instructors are lecturing.

30. I worry that I will have to use mathematics in my future career.

Appendix B - Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ)

In order to better understand what you think and feel about your college mathematics courses, please respond to each of the following statements. If there are questions you do not wish to answer, please select "No Response."

Section I

1. What is your gender? No Response Male Female
2. How many mathematics classes did you take in high school? No Response ________________
3. What was the highest mathematics course you took in high school? No Response ________________
4. What was your average grade in your mathematics classes in high school? No Response _______________
5. What was your score on the math section of the SAT? No Response ________________
6. What was your score on the University of Georgia's mathematics placement exam? No Response _____________
7. What was your score on the most recent exam in Precalculus? No Response ________________
8. How many mathematics classes, including Precalculus, have you taken in college? No Response ______________
9. How many more mathematics classes do you believe you will have to take to complete your major?
   No Response ________________

Section II	**No Response**	**Never**	**Seldom**	**Sometimes**	**Often**	**Usually**
1. I feel confident enough to ask questions in my mathematics class.	**NR**	**1**	**2**	**3**	**4**	**5**
2. I get tense when I prepare for a mathematics test.	**NR**	**1**	**2**	**3**	**4**	**5**
3. I get nervous when I have to use mathematics outside of school.	**NR**	**1**	**2**	**3**	**4**	**5**
4. I believe I can do well on a mathematics test.	**NR**	**1**	**2**	**3**	**4**	**5**
5. I worry that I will not be able to use mathematics in my future career when needed.	**NR**	**1**	**2**	**3**	**4**	**5**
6. I worry that I will not be able to get a good grade in my mathematics course.	**NR**	**1**	**2**	**3**	**4**	**5**
7. I believe I can complete all of the assignments in a mathematics course.	**NR**	**1**	**2**	**3**	**4**	**5**
8. I worry that I will not be able to do well on mathematics tests.	**NR**	**1**	**2**	**3**	**4**	**5**
9. I believe I am the kind of person who is good at mathematics.	**NR**	**1**	**2**	**3**	**4**	**5**
10. I believe I will be able to use mathematics in my future career when needed.	**NR**	**1**	**2**	**3**	**4**	**5**
11. I feel stressed when listening to mathematics instructors in class.	**NR**	**1**	**2**	**3**	**4**	**5**

12. I believe I can understand the content in a mathematics course.	**NR**	**1**	**2**	**3**	**4**	**5**
13. I believe I can get an "A" when I am in a mathematics course.	**NR**	**1**	**2**	**3**	**4**	**5**
14. I get nervous when asking questions in class.	**NR**	**1**	**2**	**3**	**4**	**5**
15. Working on mathematics homework is stressful for me.	**NR**	**1**	**2**	**3**	**4**	**5**
16. I believe I can learn well in a mathematics course.	**NR**	**1**	**2**	**3**	**4**	**5**
17. I worry that I do not know enough mathematics to do well in future mathematics courses.	**NR**	**1**	**2**	**3**	**4**	**5**
18. I worry that I will not be able to complete every assignment in a mathematics course.	**NR**	**1**	**2**	**3**	**4**	**5**
19. I feel confident when taking a mathematics test.	**NR**	**1**	**2**	**3**	**4**	**5**
20. I believe I am the type of person who can do mathematics.	**NR**	**1**	**2**	**3**	**4**	**5**
21. I feel that I will be able to do well in future mathematics courses.	**NR**	**1**	**2**	**3**	**4**	**5**
22. I worry I will not be able to understand the mathematics.	**NR**	**1**	**2**	**3**	**4**	**5**
23. I believe I can do the mathematics in a mathematics course.	**NR**	**1**	**2**	**3**	**4**	**5**
24. I worry that I will not be able to get an "A" in my mathematics course.	**NR**	**1**	**2**	**3**	**4**	**5**
25. I worry that I will not be able to learn well in my mathematics course.	**NR**	**1**	**2**	**3**	**4**	**5**
26. I get nervous when taking a mathematics test.	**NR**	**1**	**2**	**3**	**4**	**5**
27. I am afraid to give an incorrect answer during my mathematics class.	**NR**	**1**	**2**	**3**	**4**	**5**
28. I believe I can think like a mathematician.	**NR**	**1**	**2**	**3**	**4**	**5**
29. I feel confident when using mathematics outside of school.	**NR**	**1**	**2**	**3**	**4**	**5**

Appendix C - Item Correlations Between MSEAQ and Previous Scales

Table 13

Correlations between MSEAQ Self-Efficacy Items and MSES Tasks Subscale

	MSES tasks					
MSEAQ self-efficacy items	Work with calculator.	Calculate interest	Find amount of lumber	Compute income tax	Amount of material for curtains	Understand graph on profits
1. I feel confident enough to ask questions in my mathematics class.	.321*	.201	.069	-.082	-.085	-.079
4. I believe I can do well on a mathematics test.	.561**	.341*	.269	.160	.338*	.216
7. I believe I can complete all of the assignments in a math course.	.430**	.217	.113	-.042	.205	.231
9. I believe I am the kind of person who is good at mathematics.	.401**	.446*	.217	.188	.233	.301*
10. I believe I will be able to use math in my future career when needed.	.478**	.288	.399**	.229	.413**	.316*
12. I believe I can understand the content in a mathematics course.	.382*	.370*	.180	-.080	.241	.135
13. I believe I can get an "A" when I am in a mathematics course.	.530**	.440**	.298*	.094	.445**	.426**
16. I believe I can learn well in a mathematics course.	.353*	.216	.028	-.034	.187	.001
19. I feel confident when taking a mathematics test.	.589**	.276	.270	.205	.294	.295
20. I believe I am the type of person who can do mathematics.	.554**	.356*	.321*	.196	.276	.344*
21. I feel that I will be able to do well in future mathematics courses.	.356*	.412**	.321*	.241	.300*	.368*
23. I believe I can do the mathematics in a mathematics course.	.420**	.407**	.223	.076	.351*	.275
28. I believe I can think like a mathematician.	.348*	.395**	.283	.213	.108	.379*
29. I feel confident when using mathematics outside of school.	.307*	.366*	.312*	.296	.437**	.151

Note. * is $p < .05$, and ** is $p < .01$.

Table 13 (cont.)

Correlations between MSEAQ Self-Efficacy Items and MSES Tasks Subscale

	MSES tasks					
MSEAQ self-efficacy items	Interest on savings account	Add 2 large numbers in your head	Estimate your grocery bill in your head	Find sales tax on clothing purchase	Figure out tip on bill split 8 ways	Find time to drive distance
1. I feel confident enough to ask questions in my mathematics class.	.062	.125	.142	.042	-.018	.099
4. I believe I can do well on a mathematics test.	.354*	.252	-.063	-.076	.236	.350*
7. I believe I can complete all of the assignments in a mathematics course.	.243	.127	.244	.007	.148	.327*
9. I believe I am the kind of person who is good at mathematics.	.289	.077	-.155	-.151	.161	.291
10. I believe I will be able to use mathematics in my future career when needed.	.420**	.214	.137	.348*	.366*	.461**
12. I believe I can understand the content in a mathematics course.	.392**	-.032	-.012	-.114	-.011	.229
13. I believe I can get an "A" when I am in a mathematics course.	.504**	.209	-.101	-.118	.195	.486**
16. I believe I can learn well in a mathematics course.	.248	.151	-.110	-.120	.028	.169
19. I feel confident when taking a mathematics test.	.268	.107	-.101	-.179	.132	.342*
20. I believe I am the type of person who can do mathematics.	.290	.162	-.036	-.043	.232	.430**
21. I feel that I will be able to do well in future mathematics courses.	.456**	.111	-.143	-.074	.114	.396**
23. I believe I can do the mathematics in a mathematics course.	.487**	.153	.041	-.041	.099	.315*
28. I believe I can think like a mathematician.	.327*	.161	-.074	-.048	.093	.274
29. I feel confident when using mathematics outside of school.	.463**	.208	.061	.136	.083	.321*

Note. * is $p < .05$, and ** is $p < .01$.

Table 13 (cont.)

Correlations between MSEAQ Self-Efficacy Items and MSES Tasks Subscale

	MSES tasks					
MSEAQ self-efficacy items	Compute a car's gas mileage	Set up a monthly budget for yourself	Balance your checkbook with no mistakes	Figure out the better of two job offers	Figure out savings on a 15% markdown	Calculate recipe of 12 for 41 people
1. I feel confident enough to ask questions in my mathematics class.	.187	-.032	.124	.021	.190	-.048
4. I believe I can do well on a mathematics test.	.349*	.141	.257	.228	.365*	.000
7. I believe I can complete all of the assignments in a mathematics course.	.373*	.118	.403**	.229	.461**	-.014
9. I believe I am the kind of person who is good at mathematics.	.390**	.132	.290	.058	.246	.283
10. I believe I will be able to use mathematics in my future career when needed.	.512**	.211	.534**	.339*	.616**	.292
12. I believe I can understand the content in a mathematics course.	.281	.157	.384**	.327*	.343*	.029
13. I believe I can get an "A" when I am in a mathematics course.	.425**	.231	.346*	.254	.341*	.201
16. I believe I can learn well in a mathematics course.	.201	-.097	.268	.250	.322*	-.069
19. I feel confident when taking a mathematics test.	.341*	.064	.226	.087	.397**	.165
20. I believe I am the type of person who can do mathematics.	.489**	.157	.339*	.089	.388**	.328*
21. I feel that I will be able to do well in future mathematics courses.	.443**	.137	.374*	.193	.386**	.342*
23. I believe I can do the mathematics in a mathematics course.	.402**	.149	.318*	.357*	.362*	.034
28. I believe I can think like a mathematician.	.397**	-.020	.257	.158	.199	.223
29. I feel confident when using mathematics outside of school.	.371*	.290	.590**	.537**	.302*	.233

Note. * is $p < .05$, and ** is $p < .01$.

Table 14

Correlations between MSEAQ Anxiety Items and s-MARS Items

	s-MARS items					
MSEAQ anxiety items	Taking a final exam in math	Thinking about a test 1 week before	Thinking about a test 1 day before	Thinking about a test 1 hour before	Thinking about a test 5 minutes before	Waiting to get a test returned
2. I get tense when I prepare for a mathematics test.	.738**	.734**	.806**	.707**	.475**	.404**
3. I get nervous when I have to use mathematics outside of school.	.100	.267	.235	.196	.209	.046
5. I worry that I will not be able to use mathematics in my future career when needed.	.275	.335*	.366*	.378*	.376*	.400*
6. I worry that I will not be able to get a good grade in my mathematics course.	.618**	.701**	.703**	.586**	.485**	.333*
8. I worry that I will not be able to do well on mathematics tests.	.684**	.710**	.734**	.625**	.437**	.382*
11. I feel stressed when listening to mathematics instructors in class.	.389**	.424**	.322*	.108	.191	.272
14. I get nervous when asking questions in class.	.194	.415**	.237	.199	.196	.294*
15. Working on mathematics homework is stressful for me.	.556**	.526**	.577**	.523**	.308*	.228
17. I worry that I do not know enough mathematics to do well in future mathematics courses.	.385**	.360*	.493**	.504**	.400**	.099
18. I worry that I will not be able to complete every assignment in a mathematics course.	.272	.373*	.362*	.260	.275	-.005
22. I worry I will not be able to understand the mathematics.	.575**	.581**	.624**	.492**	.428**	.364*
24. I worry that I will not be able to get an “A” in my mathematics course.	.546**	.581**	.692**	.567**	.408**	.236
25. I worry that I will not be able to learn well in my mathematics course.	.519**	.633**	.554**	.421**	.301*	.375*
26. I get nervous when taking a mathematics test.	.731**	.710**	.784**	.726**	.475**	.541**
27. I am afraid to give an incorrect answer during my mathematics class.	.462**	.523**	.618**	.503**	.257	.408**

Note. * is $p < .05$, and ** is $p < .01$.

Table 14 (cont.)

Correlations between MSEAQ Anxiety Items and s-MARS Items

	s-MARS items					
MSEAQ anxiety items	Receiving final grade in the mail	Realizing how many math courses are left	Being given a "pop" quiz in math	Studying for a mathematics test	Taking the math section of a college entrance	Taking a quiz in math
2. I get tense when I prepare for a mathematics test.	.202	.530**	.319*	.672**	.525**	.455**
3. I get nervous when I have to use mathematics outside of school.	.028	.208	.053	.290	.286	.284
5. I worry that I will not be able to use mathematics in my future career when needed.	.296*	.432*	.258	.349*	.119	.114
6. I worry that I will not be able to get a good grade in my mathematics course.	.366*	.615**	.027	.682**	.295*	.343*
8. I worry that I will not be able to do well on mathematics tests.	.265	.584**	.092	.592**	.372*	.342*
11. I feel stressed when listening to mathematics instructors in class.	.336*	.252	.138	.254	.104	.386*
14. I get nervous when asking questions in class.	.383**	.445**	.091	.326*	.175	.174
15. Working on mathematics homework is stressful for me.	.126	.449**	.430**	.681**	.341*	.372*
17. I worry that I do not know enough mathematics to do well in future mathematics courses.	.289	.530**	.126	.485**	.293	.264
18. I worry that I will not be able to complete every assignment in a mathematics course.	.120	.454**	.132	.572**	.058	.295
22. I worry I will not be able to understand the mathematics.	.281	.609**	.302*	.668**	.260	.436**
24. I worry that I will not be able to get an "A" in my mathematics course.	.293	.409**	.184	.657**	.358*	.438**
25. I worry that I will not be able to learn well in my mathematics course.	.407**	.543**	.248	.604**	.348*	.413**
26. I get nervous when taking a mathematics test.	.360*	.515**	.381*	.575**	.400**	.544**
27. I am afraid to give an incorrect answer during my mathematics class.	.216	.424**	.329*	.375*	.366*	.224

Note. * is $p < .05$, and ** is $p < .01$.

Table 14 (cont.)

Correlations between MSEAQ Anxiety Items and s-MARS Items

MSEAQ anxiety items	s-MARS items: Picking up math textbook to work on hw	Given a tough hw which is due next class	Getting ready to study for a math test	Dividing 5 digit number by 2 digit in private	Adding 976 and 777 on paper	Reading a cash register receipt
2. I get tense when I prepare for a mathematics test.	.560**	.622**	.687**	.199	.092	.123
3. I get nervous when I have to use mathematics outside of school.	.337*	.129	.330*	.125	.277	.014
5. I worry that I will not be able to use mathematics in my future career when needed.	.289	.428**	.398**	.170	.212	.273
6. I worry that I will not be able to get a good grade in my mathematics course.	.533**	.416**	.660**	.040	.196	.010
8. I worry that I will not be able to do well on mathematics tests.	.452**	.333*	.609**	.005	.023	.055
11. I feel stressed when listening to mathematics instructors in class.	.386**	.193	.315*	.000	.340*	-.110
14. I get nervous when asking questions in class.	.528**	.374*	.460**	.002	.428**	.012
15. Working on mathematics homework is stressful for me.	.536**	.501**	.602**	.109	.126	.066
17. I worry that I do not know enough mathematics to do well in future mathematics courses.	.373*	.450**	.447**	.248	.304*	.106
18. I worry that I will not be able to complete every assignment in a mathematics course.	.512**	.405**	.527**	.227	.351*	.028
22. I worry I will not be able to understand the mathematics.	.542**	.448**	.635**	.127	.288	.138
24. I worry that I will not be able to get an “A” in my mathematics course.	.599**	.524**	.755**	.180	.204	.101
25. I worry that I will not be able to learn well in my mathematics course.	.529**	.366*	.563**	.046	.408**	-.086
26. I get nervous when taking a mathematics test.	.472**	.531**	.635**	.094	.215	.119
27. I am afraid to give an incorrect answer during my mathematics class.	.417**	.565**	.510**	.388**	.200	.322*

Note. * is $p < .05$, and ** is $p < .01$.

Table 14 (cont.)

Correlations between MSEAQ Anxiety Items and s-MARS Items

	s-MARS items					
MSEAQ anxiety items	Figuring the sales tax on a purchase that is over $1	Figuring out your monthly budget	Being given a set of addition problems to solve on paper	Someone watching you add a column of figures	Totaling a dinner bill that you think overcharged you	Being responsible for collecting dues
2. I get tense when I prepare for a mathematics test.	-.016	.063	.007	.279	.286	.222
3. I get nervous when I have to use mathematics outside of school.	.083	.362*	.235	.404**	.280	.307*
5. I worry that I will not be able to use mathematics in my future career when needed.	.307*	.270	.265	.409**	.529**	.450**
6. I worry that I will not be able to get a good grade in my mathematics course.	.113	.032	.117	.159	.178	.176
8. I worry that I will not be able to do well on mathematics tests.	-.040	-.174	.048	-.006	.112	.048
11. I feel stressed when listening to mathematics instructors in class.	-.188	-.042	.158	.075	-.038	.050
14. I get nervous when asking questions in class.	.225	.192	.275	.067	.170	.273
15. Working on mathematics homework is stressful for me.	-.114	.137	-.050	.273	.224	.240
17. I worry that I do not know enough mathematics to do well in future mathematics courses.	.146	.085	-.092	.098	.368*	.307*
18. I worry that I will not be able to complete every assignment in a mathematics course.	.053	.218	.224	.252	.226	.363*
22. I worry I will not be able to understand the mathematics.	.021	.146	.176	.269	.316*	.424**
24. I worry that I will not be able to get an “A” in my mathematics course.	.119	.171	.183	.370*	.384*	.428**
25. I worry that I will not be able to learn well in my mathematics course.	-.037	.114	.118	.153	.139	.362*
26. I get nervous when taking a mathematics test.	-.043	.049	.092	.211	.340*	.288
27. I am afraid to give an incorrect answer during my mathematics class.	.189	.149	.195	.185	.363*	.348*

Note. * is $p < .05$, and ** is $p < .01$.

Table 14 (cont.)

Correlations between MSEAQ Anxiety Items and s-MARS Items

	s-MARS items					
MSEAQ anxiety items	Memorizing numbers needed for a drivers' test	Totaling up dues for club you belong to	Watching someone work with a calculator	Being given a set of division problems	Being given a set of sub problems	Being given a set of multiplication problems
2. I get tense when I prepare for a mathematics test.	.322*	.081	.076	.190	.062	.245
3. I get nervous when I have to use mathematics outside of school.	.359*	.258	.293	.187	.192	.378*
5. I worry that I will not be able to use mathematics in my future career when needed.	.427**	.330*	.182	.369*	.396**	.359*
6. I worry that I will not be able to get a good grade in my mathematics course.	.145	.036	.009	.204	.045	.098
8. I worry that I will not be able to do well on mathematics tests.	.050	-.127	-.045	.145	.030	.020
11. I feel stressed when listening to mathematics instructors in class.	.209	.112	.059	.079	.048	.200
14. I get nervous when asking questions in class.	.153	.180	-.036	.081	.132	.254
15. Working on mathematics homework is stressful for me.	.177	.059	.057	.168	-.067	.129
17. I worry that I do not know enough mathematics to do well in future mathematics courses.	.119	.065	.091	.185	-.074	.185
18. I worry that I will not be able to complete every assignment in a mathematics course.	.359*	.126	-.137	.242	.078	.249
22. I worry I will not be able to understand the mathematics.	.381**	.053	.173	.271	.100	.277
24. I worry that I will not be able to get an "A" in my mathematics course.	.396**	.205	.132	.322*	.155	.283
25. I worry that I will not be able to learn well in my mathematics course.	.429**	.095	.004	.220	.150	.184
26. I get nervous when taking a mathematics test.	.281	.117	.143	.275	.153	.160
27. I am afraid to give an incorrect answer during my mathematics class.	.340*	.160	.068	.278	.180	.231

Note. * is $p < .05$, and ** is $p < .01$.

Appendix D – Pattern and Structure Matrices for EFA

Table 15

Pattern Matrix for EFA

	Factor				
	1	2	3	4	5
I believe I am the kind of person who is good at mathematics.	.829*	.101	.053	-.049	-.182
I believe I am the type of person who can do mathematics.	.820*	.123	.066	-.026	-.157
I believe I can learn well in a mathematics course.	.725*	-.137	.138	-.064	.069
I feel that I will be able to do well in future mathematics courses.	.612*	.064	-.020	.057	.211
I believe I can understand the content in a mathematics course.	.541*	-.027	.018	.223	.090
I believe I can get an “A” when I am in a mathematics course.	.538*	.513*	-.138	-.021	-.098
I believe I can do the mathematics in a mathematics course.	.518*	-.063	.309	.045	.117
I worry that I will not be able to do well on mathematics tests.	.085	.850*	.014	-.109	.066
I get tense when I prepare for a mathematics test.	-.035	.825*	.086	-.045	-.038
I get nervous when taking a mathematics test.	.046	.798*	.032	.048	-.090
I worry that I will not be able to get an “A” in my mathematics course.	-.128	.725*	.154	.077	-.150
I worry that I will not be able to get a good grade in my mathematics course.	.260	.706*	-.056	-.184	.164
I feel confident when taking a mathematics test.	.278	.658*	-.132	.078	-.010
I believe I can do well on a mathematics test.	.383	.473*	-.207	.098	.174
Working on mathematics homework is stressful for me.	-.329	.417*	.253	.119	.313

Note. * indicates significant loading onto factor.

Table 15 (cont.)

Pattern Matrix for EFA

	Factor				
	1	2	3	4	5
I get nervous when I have to use mathematics outside of school.	-.056	.099	.752*	-.098	-.107
I feel confident when using mathematics outside of school.	.179	-.121	.687*	-.037	-.121
I worry that I will not be able to use mathematics in my future career when needed.	-.105	.006	.615*	.015	.152
I worry I will not be able to understand the mathematics.	.273	.017	.573*	-.070	.027
I worry that I will not be able to learn well in my mathematics course.	.215	.152	.541*	.055	.040
I feel stressed when listening to mathematics instructors in class.	-.009	.116	.513*	.232	.031
I believe I will be able to use mathematics in my future career when needed.	.345	-.178	.477*	.157	-.093
I worry that I do not know enough mathematics to do well in future mathematics courses.	.106	.160	.437*	.018	.107
I am afraid to give an incorrect answer during my mathematics class.	-.172	.222	.336	.314	-.112
I feel confident enough to ask questions in my mathematics class.	.107	-.125	-.178	.987*	.147
I get nervous when asking questions in class.	-.030	.104	.234	.626*	-.095
I believe I can complete all of the assignments in a mathematics course.	-.001	-.026	-.106	.120	.736*
I worry that I will not be able to complete every assignment in a mathematics course.	.043	-.125	.451	-.233	.471*

Note. * indicates significant loading onto factor.

Table 16

Structure Matrix for EFA

	Factor 1	2	3	4	5
I believe I am the type of person who can do mathematics.	0.868	0.607	0.462	0.238	0.219
I believe I am the kind of person who is good at mathematics.	0.842	0.563	0.420	0.198	0.179
I believe I can get an "A" when I am in a mathematics course.	0.757	0.730	0.363	0.269	0.251
I feel that I will be able to do well in future mathematics courses.	0.734	0.560	0.439	0.259	0.460
I believe I can learn well in a mathematics course.	0.714	0.404	0.426	0.123	0.326
I believe I can do the mathematics in a mathematics course.	0.686	0.511	0.604	0.294	0.423
I believe I can understand the content in a mathematics course.	0.621	0.468	0.408	0.366	0.315
I worry that I will not be able to do well on mathematics tests.	0.633	0.891	0.510	0.304	0.448
I worry that I will not be able to get a good grade in my mathematics course.	0.698	0.829	0.461	0.194	0.507
I get nervous when taking a mathematics test.	0.552	0.828	0.478	0.415	0.286
I get tense when I prepare for a mathematics test.	0.512	0.814	0.491	0.344	0.331
I feel confident when taking a mathematics test.	0.649	0.793	0.400	0.382	0.323
I believe I can do well on a mathematics test.	0.670	0.720	0.365	0.340	0.435
I worry that I will not be able to get an "A" in my mathematics course.	0.378	0.699	0.459	0.412	0.191
Working on mathematics homework is stressful for me.	0.208	0.533	0.511	0.375	0.500
I worry that I will not be able to learn well in my mathematics course.	0.610	0.632	0.774	0.411	0.431
I worry I will not be able to understand the mathematics.	0.561	0.490	0.700	0.252	0.378
I get nervous when I have to use mathematics outside of school.	0.319	0.392	0.690	0.236	0.236
I feel stressed when listening to mathematics instructors in class.	0.390	0.511	0.685	0.503	0.338
I worry that I will not be able to use mathematics in my future career when needed.	0.263	0.351	0.640	0.274	0.392
I feel confident when using mathematics outside of school.	0.390	0.307	0.639	0.228	0.194
I worry that I do not know enough mathematics to do well in future mathematics courses.	0.469	0.524	0.634	0.316	0.411
I believe I will be able to use mathematics in my future career when needed.	0.474	0.338	0.575	0.353	0.192
I feel confident enough to ask questions in my mathematics class.	0.237	0.346	0.290	0.903	0.194
I get nervous when asking questions in class.	0.275	0.453	0.501	0.751	0.132
I am afraid to give an incorrect answer during my mathematics class.	0.174	0.390	0.457	0.496	0.113
I believe I can complete all of the assignments in a mathematics course.	0.227	0.280	0.257	0.167	0.694
I worry that I will not be able to complete every assignment in a mathematics course.	0.301	0.249	0.513	-0.020	0.601