2012

A DESCRIPTIVE, SURVEY RESEARCH STUDY OF THE STUDENT CHARACTERISTICS INFLUENCING THE FOUR THEORETICAL SOURCES OF MATHEMATICAL SELF-EFFICACY OF COLLEGE FRESHMEN

Tonja Motley Locklear
University of Kentucky, tlocklear@averett.edu

STUDENT AGREEMENT:

I represent that my thesis or dissertation and abstract are my original work. Proper attribution has been given to all outside sources. I understand that I am solely responsible for obtaining any needed copyright permissions. I have obtained and attached hereto needed written permission statements(s) from the owner(s) of each third-party copyrighted matter to be included in my work, allowing electronic distribution (if such use is not permitted by the fair use doctrine).

I hereby grant to The University of Kentucky and its agents the non-exclusive license to archive and make accessible my work in whole or in part in all forms of media, now or hereafter known. I agree that the document mentioned above may be made available immediately for worldwide access unless a preapproved embargo applies.

I retain all other ownership rights to the copyright of my work. I also retain the right to use in future works (such as articles or books) all or part of my work. I understand that I am free to register the copyright to my work.

REVIEW, APPROVAL AND ACCEPTANCE

The document mentioned above has been reviewed and accepted by the student's advisor, on behalf of the advisory committee, and by the Director of Graduate Studies (DGS), on behalf of the program; we verify that this is the final, approved version of the student's dissertation including all changes required by the advisory committee. The undersigned agree to abide by the statements above.

Tonja Motley Locklear, Student

Dr. Margaret J. Mohr-Schroeder, Major Professor

Dr. Robert Shapiro, Director of Graduate Studies

A DESCRIPTIVE, SURVEY RESEARCH STUDY OF THE STUDENT CHARACTERISTICS INFLUENCING THE FOUR THEORETICAL SOURCES OF MATHEMATICAL SELF-EFFICACY OF COLLEGE FRESHMEN

DISSERTATION

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in the
College of Education
at the University of Kentucky

By
Tonja Motley Locklear

Lexington, Kentucky

Co-Directors: Dr. Margaret J. Mohr-Schroeder, Assistant Professor of Mathematics Education
and Dr. Carl W. Lee , Professor of Mathematics

Lexington, Kentucky

ABSTRACT OF DISSERTATION

A DESCRIPTIVE, SURVEY RESEARCH STUDY OF THE STUDENT CHARACTERISTICS INFLUENCING THE FOUR THEORETICAL SOURCES OF MATHEMATICAL SELF-EFFICACY OF COLLEGE FRESHMEN

The Sources of Middle School Mathematics Self-Efficacy Scale (Usher & Pajares, 2009) was adapted for use in this study investigating the impact that gender, race, sexual orientation, hometown location (rural, suburban, or urban), high school GPA, college GPA and letter grade of a mathematics course in the previous semester had on the four sources of mathematical self-efficacy of 102 college freshmen attending three small, private, liberal arts institutions. Even though this study found no interaction effects between the student characteristics, the four sources of mathematical self-efficacy, or the three subcategories of the vicarious experience construct, this study did find statistically significant results for several independent variables: gender, hometown environment, and the letter grade received in the mathematics course the preceding semester at the Bonferroni correction rate of .025. Additionally, small p-values for race and hometown environments warrant further investigation with a larger sample size.

KEYWORDS: Sources of Mathematical Self-Efficacy, Self-Efficacy, Mathematical Self-Efficacy, Mathematics Education, Post-secondary Education

Tonja Motley Locklear

June 20, 2012

A DESCRIPTIVE, SURVEY RESEARCH STUDY OF THE STUDENT CHARACTERISTICS INFLUENCING THE FOUR THEORETICAL SOURCES OF MATHEMATICAL SELF-EFFICACY OF COLLEGE FRESHMEN

BY

Tonja Motley Locklear

Margaret J. Mohr-Schroeder, Ph. D.
Co-Director of Dissertation

Carl W. Lee, Ph. D.
Co-Director of Dissertation

Robert Shapiro, Ph. D.
Director of Graduate Studies

June 20, 2012

I would like to dedicate this work to my wonderful children, Hannah and Peyton,
who had to suffer through my frustrations, lack of quality time,
and stressful deadlines. May you both realize that nothing is impossible
as long as you have the support of loving family and friends,
set your goals, work hard and pray even harder.

I LOVE YOU!

ACKNOWLEDGEMENTS

Even though this paper was my own work, it would not have been possible without the support and guidance of many people:

ACCLAIM Doctoral Program Coordinators and Professors – Without this particular program offered by the collaboration of many outstanding professors from five universities, I would NEVER have had the opportunity to fulfill my dream. THANK YOU for your innovation and dedication to education!

ACCLAIM Cohort III – Without your own stories, experiences, knowledge and support, my understanding of mathematics teacher education would not have evolved. THANK YOU for making me a stronger mathematics educator!

Study Buddies – Without your support and encouragement throughout each of the 5-week summer sessions, as well as all of the online courses, I would not have felt as confident to press forward. Each of you has exemplified courage, strength and friendship through your own personal obstacles and setbacks. THANK YOU for always being there to listen!

Dr. Margaret Schroeder and Dr. Carl Lee – Without your guidance and support as ACCLAIM professors and co-chairs of my dissertation committee, I would not have felt as prepared and confident during my defense. I hope you will forgive my tireless need to press forward, which may have rocked the boat on occasion. THANK YOU for your support and encouragement throughout this strenuous process!

Dr. Kenneth Tyler and Dr. Jennifer Wilhelm – Without your additional guidance and knowledge, I would not have focused on generating such a comprehensive study. Your questions and discussions during my qualifying examination and my proposal defense created additional layers of my knowledge of self-efficacy and my study of its sources. THANK YOU for illuminating the areas that needed more investigation!

Mom and Dad – Without your support, encouragement, and love, I would not have been able to accomplish this goal. Knowing that I could always count on you to watch the children provided such a peace of mind that allowed me to focus on the work at hand. THANK YOU for providing the foundation during my childhood that said that hard work will allow you to accomplish your goals!

My Husband – Without your understanding and support during this past year, I would not have been able to complete my dissertation. You allowed me to spend COUNTLESS hours working on “this little paper” without MUCH complaining during our FIRST year of marriage. Your support and love has meant so much to me. THANK YOU for allowing me the space to complete my professional dream!!!!

God – THANK YOU for the wisdom, the strength, the perseverance and the ability!

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter I: Introduction

Since the emergence of self-efficacy as a component of Albert Bandura's social cognitive theory in 1977, much research has been conducted on how this construct affects learning. Similarly, with the emergence over the past 30 years of mathematics being a significant subject of discussion in education and politics as seen by publications such as *Nation at Risk*, NCTM's *Principles and Standards for School Mathematics*, *No Child Left Behind*, and more recently the, *Common Core State Standards Initiative* much research has been directed towards understanding and improving the mathematical achievement of United States' students. It is no surprise then that these two areas of research have resulted in many studies focusing on the effects of self-efficacy on mathematics achievement. Consequently, the research has shown in school mathematics that "perceived self-efficacy contributes to academic performance irrespective of the level of intellectual ability, and correlates strongly with academic outcomes, such as performance in problem solving, attitudes towards mathematics and math anxiety" (Michaelides, 2008, p. 222).

Even though studying the effects of self-efficacy on mathematics achievement of students in elementary, middle and even high school could result in interventions that may produce improvements for not only the students but also mathematics education in general, studying the effects on the collegiate level is just as significant and important. The number of students enrolling in colleges or universities over the past few decades has steadily increased and students' academic choices regarding mathematics have been acknowledged to not only affect a student's choice in a college major, but also to influence a student's likelihood for completing his or her college education (Hall &

Ponton, 2005). If the issues regarding self-efficacy and mathematics achievement are not resolved during the K-12 years, then those same issues will be found on the collegiate level and may become worse by the increase in stress associated with freshmen students.

In Pajares' (1996) review of the educational research of academic self-efficacy, he acknowledged the sound connection between self-efficacy and academic performances and achievement established through abundant research. Since this connection has been well established, the focus needs to shift toward research on how to enhance students' level of self-efficacy through various sources of information. Lent, Lopez, Brown and Gore (1996) determined through confirmatory factor analysis that the four theorized sources of mathematical self-efficacy represent different types of information and, therefore, can be analyzed separately. Additionally, they posited the need "to clarify how the efficacy sources are structured in other populations and performance domains and whether the theoretical distinctions among the sources can inform interventions aimed at modifying self-efficacy percepts" (Lent et al., 1996, p. 306).

Theoretical Framework

Self-Efficacy. Self-efficacy is a component of Albert Bandura's social cognitive theory and is referred to as the "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997, p. 3). Thus, the mathematical self-efficacy of students is their belief about their capabilities to control the outcome regarding their mathematical performance. For this research study the definition of *mathematical self-efficacy* will be "the level of an individual's belief in his/her competence to attain a favorable outcome regarding their mathematical performance". Bandura goes on to state,

> Such beliefs influence the courses of action people choose to pursue, how much effort they put forth in given endeavors, how long they will persevere in the face of obstacles and failures, their resilience to adversity, whether their thought patterns are self-hindering or self-aiding, how much stress and depression they experience in coping with taxing environmental demands, and the level of accomplishments they realize. (p. 3)

Hence, students with higher levels of mathematical self-efficacy will exert more effort, maintain their desire to persevere, and continue working towards successful results in their mathematics classes. Basically, what students believe they can or cannot accomplish is a driving force for them to actualize that success or failure.

Sources of Self-Efficacy. All self-efficacy judgments, including mathematical self-efficacy, are based on how each person processes various pieces of information. According to Bandura (1997), this cognitive processing takes place in two distinct steps. The first step involves which type of information a person uses in the process. The second step involves the amount of importance a person attributes to the various types of information. Bandura theorized that self-efficacy is formed through the cognitive processing of four sources of information: mastery experiences, vicarious experiences, verbal and social persuasions, and physiological and emotional states.

Mastery experiences refers to the cognitive processing of previous successes and failures, which produce an internal view on an individual's capabilities. Once processed, mastery experiences could enhance, reduce or make no change at all in an individual's feelings of self-efficacy. *Vicarious experiences* refers to the cognitive processing of an individual's capabilities compared to the capabilities of others. An individual may look to role models to substantiate their own level of self-efficacy for various situations. Adult role models, peer role models, and self-generated role models divide vicarious experience into three subsections. *Verbal and social persuasions* refers to the cognitive processing of the faith, or lack thereof, others have in an individual's abilities. The knowledge and credibility of the other person makes a difference in the level of influence of this source of self-efficacy. Finally, *physiological and emotional states* refers to the cognitive processing of an individual's capabilities based on somatic information. Anxiety is a common somatic indicator associated with mathematics, which may affect how efficacious a person feels toward mathematics success (Bandura, 1997).

Statement of the Problem

Post-secondary education faces multiple challenges in providing the best environment to assist students from matriculation to graduation. Mathematics has been one area of contention with college students for years. "Knowing how to build a sense of efficacy and how it works provides further guidelines for structuring experiences that enable people to realize desired personal and social changes" (Bandura, 2006, p. 319). In order to create the experiences to enhance the mathematical self-efficacy of college students, more information is needed on how the different sources of self-efficacy impact various people and/or groups of people.

Bandura (1997) posited that mastery experience is the strongest source of self-efficacy, but Stevens et al. (2004), stated that previous mathematics achievement (mastery experience) influenced the self-efficacy of Hispanic students in their study, but did not have a statistically significant impact on the Caucasian students. However, they used the students' self-reported prior mathematics grades to represent the mastery experience construct, which does not evaluate the students' interpretation of those grades. Their study and many others (Matsui, Matsui, & Ohnishi, 1990; Ozyurek, 2005) have conducted research claiming to analyze one or more of the sources of self-efficacy without using a calibrated assessment tool specifically designed for those sources of mathematical self-efficacy or have deviated from the tenets of the theory. A thorough study of the sources of mathematical self-efficacy and their influence on various groups of college students utilizing a valid and calibrated assessment tool is needed to enhance and further this research.

Purpose of the Study

The purpose of this descriptive, survey research study was to determine which student characteristics (race, gender, sexual orientation and hometown location) influence the sources of mathematical self-efficacy of college freshmen, if any, utilizing a valid assessment tool aligned with the tenets of the self-efficacy theory.

Research Question

This research study investigated the four sources of mathematical self-efficacy of college freshmen. More specifically it addressed the following research question:
What student characteristics influence the four sources of mathematical self-efficacy, if any?
"Because personal agency is socially rooted and operates within sociocultural influences, individuals are viewed both as products and producers of their own environments and of their social systems" (Pajares, 1996, p. 544). The hypothesis for this study is that groups of students will be influenced by similar sources of self-efficacy (i.e. the *vicarious experience* score of students will be influenced by their race or the *verbal and social persuasion* score will be influenced by a student's hometown location). However, the fact that every person belongs to various groups may lessen one particular source for him/her

while strengthening another. The overlapping of environmental, personal and behavioral aspects within each person makes the sources of mathematical self-efficacy construct harder to analyze.

Significance of the Study

Although self-efficacy has been broadly researched over the past 30 years since Bandura introduced the construct (Pajares, 1997), little research has been conducted on the impact of the sources of mathematical self-efficacy on groups of college students based on gender, race, sexual orientation and hometown location (rural, urban or suburban). Moreover, the research on the sources of mathematical self-efficacy has been inconsistent because of the manner in which the sources have been "operationalized and assessed" (Usher & Pajares, 2009, p. 90). This study will contribute to the literature on the sources of mathematical self-efficacy by examining the impact of student characteristics on the construct using a valid assessment scale.

Definition of Terms

The following is a list of terms and definitions that will be used throughout this study.

Mathematical Self-Efficacy – the level of an individual's belief in his/her competence to attain a favorable outcome regarding their mathematical performance

Sources of Self-Efficacy – the four theoretical sources of information used by individuals to construct their own level of competence regarding their mathematical performance

Mastery Experiences – cognitive processing of competence generated by an individual's previous successes and failures

Vicarious Experiences – cognitive processing of competence generated by the comparisons of oneself with others (adult, peer or self-generated role models)

Verbal and Social Persuasions – cognitive processing of competence generated by verbal and social encouragement or discouragement of others

Physiological and Emotional States – cognitive processing of competence generated by an individual's emotions or physiological state

Assumptions

1. The participants provided accurate demographic information on the surveys.
2. The participants were honest and reflective in their responses to the survey questions.
3. All of the participants were accessible by email.
4. The email address provided by the college was accurate.
5. The intended recipient actually answered the survey only once.

Limitations

Since it was not possible to survey all freshmen–level college students in small, private, 4-year institutions, this study was limited to the students enrolled in three universities selected through a customized list of institutions based on the Carnegie Foundation Classification system. The study consisted of 106 college freshmen students attending small, private institutions. Based on the three institutions that chose to participate in the research study, the sample of college freshmen were selected from religiously affiliated institutions. This religiously affiliated, small sample within the college student population limits the generalizability of the findings.

Furthermore, even though the four theorized sources of mathematical self-efficacy address distinct sources of information, and therefore, can be analyzed separately (Lent, Lopez, Brown, & Gore, 1996), the overlapping of environmental, personal and behavioral aspects within each person makes the sources of mathematical self-efficacy construct harder to analyze.

Organization of the Study

This research study is organized into five chapters, a bibliography, and appendices as follows:

Chapter I: Introduction

Chapter II: Review of Literature

Chapter III: Methodology

Chapter IV: Results and Analysis

Chapter V: Discussion, Conclusions, and Implications

The first chapter provides introductory information for this dissertation study, including the purpose and significance of the study. The second chapter provides the review of the literature pertinent to this dissertation, including mathematics self-efficacy and sources of mathematics self-efficacy. The third chapter provides the research design of this dissertation and the methodology for conducting the research. The fourth chapter of the dissertation explains the data analysis and results from the study. The final chapter provides a discussion of the findings and their implications, as well as recommendations for future research.

Chapter II: Review of Literature

This chapter contains the review of the relevant literature for this dissertation. Bandura (1997) refers to the multifaceted aspect of self-efficacy when describing the manner in which one should try to measure this particular construct. A person can have a high sense of self-efficacy in regard to one particular situation and a low sense of self-efficacy regarding another. Since the level of self-efficacy is dependent on the particular aspects surrounding the topic, then it is important to delineate the specific construct being studied and the particular parameters regarding the study in order to ascertain the most reliable analysis (Bandura, 1997). This plays a significant role in the analysis of research studies pertaining to self-efficacy. Literature focusing on mathematical self-efficacy and the sources of mathematical self-efficacy is investigated for this research study with attention to the tenets of Bandura's social cognitive theory.

Mathematical Self-Efficacy

Wadsworth, Husman, Duggan, and Pennington (2007) investigated which of the constructs (self-efficacy, attitude, motivation, time management, anxiety, concentration, information processing, selecting main ideas, use of supporting materials, testing strategies and self-testing) impact student success when instruction is provided in an online learning environment. They found that the success of students (89 out of 511 self-selecting to participate) participating in an online developmental mathematics course was due, in part, to mathematical self-efficacy, motivation, concentration, information processing, and self-testing skills. However, the students' achievement was based on their overall grade for the course and each participant received extra credit for completing the various surveys that were given periodically throughout the semester. Thus, their overall achievement score may not speak to the actual ability of the students. Additionally, they reported that the self-efficacy of students taking online classes was not substantially different than from students who took a traditionally delivered course. However, the self-efficacy survey questions were only given to students who took a course online and the survey described was not a known, calibrated assessment of self-efficacy. Thus, this generalized statement has no merit within the confines of the research study.

Spence & Usher (2007) attempted to determine how motivation variables, mathematics self-efficacy and a particular computer courseware (MyMathLab) affected student achievement. Their study included 164 students who were enrolled in either one of the eight sections of traditionally taught courses or one of the eight sections of online courses at a particular university and who completed both surveys and took the final exam. The final exam was the assessment tool for determining mathematics achievement, because all students were required to take this 40-item multiple-choice departmental test. Even though Spence and Usher acknowledged the use of Bandura's *Guide for Constructing Self-Efficacy Scales* as their reasoning for the questions used within the surveys to assess self-efficacy, the survey was not a known, calibrated measure.

Spence and Usher (2007) found that the mathematics self-efficacy was higher in those enrolled in the traditional courses than those in the online courses. The students in the traditional courses also scored higher on their final exams. When researchers controlled for mathematics self-efficacy, they claimed that the poorer performance of the online students was associated with their lower self-efficacy beliefs. Compared to the other variables (self-efficacy for self-regulation, computer self-efficacy, computer playfulness, engagement and age), they determined that mathematics self-efficacy was the strongest predictor of achievement. However, there were some validity issues that need to be considered within the context of this study. Those students taking courses online were required to take a written mathematics test. This change in assessment style from computerized to written may account for the poorer scores on the final exam. Additionally, those students enrolled in the traditional courses were allowed to use MyMathLab courseware as a supplement, which could confound the results of the achievement assessment.

Hall and Ponton (2005) focused on the comparison of the mathematics self-efficacy of freshmen students taking developmental mathematics courses with those taking Calculus I. After hypothesizing that participation in the study would have no positive or negative effect on the students' grade for the semester, 80 students within the four Calculus I sections and 105 students within the four developmental sections agreed to participate. The students were given two subscales (Mathematics Tasks subscale and Mathematics Courses subscale) of the revised Mathematical Self-Efficacy Scale (MSES), which produced their overall self-efficacy score. Using an independent *t*-test and an ANOVA, the results showed a statistically significant difference between the self-efficacy of freshmen students in the developmental mathematics courses and those in the Calculus I courses with the latter having the higher level of self-efficacy. Additionally, gender did not statistically significantly affect students' mathematical self-efficacy in either the developmental or Calculus I courses. Even though the results of this study did not appear to be confounded by internal validity issues, the small sample size limits the generalizability of these results.

Hailikari, Nevgi and Komulainen (2008) investigated the connection of prior knowledge and academic self-beliefs (combination of expectations of success, mathematical self-efficacy, and self-perception of mathematical ability) on mathematics achievement with participants who were mathematics students in a required undergraduate mathematics class where 67% were first-year students. Instead of using a known, calibrated self-efficacy scale, Hailikari et al. used nine statements to assess academic self-beliefs. Three of the statements were used to measure expectations of success, four measured self-efficacy and two items, created by them solely for this study, measured self-perceptions of mathematics ability. Prior knowledge was measured using six mathematical problem solving tasks using mathematics skills that were considered required skills of students before the beginning of the course. Student achievement was measured by the final grade in the course. They found that prior knowledge predicted a student's academic achievement over all of the other variables.

Within the statistical analysis of the study, Hailikari et al. (2008) described the procedure they used to impute the missing values of 21 final grades using different statistical programs, because the data were considered missing at random. They determined that the different methods produced basically the same results, which were then used to supply the overall academic achievement score for those students. However, imputing 21 out of 139 (15%) of the student's overall achievement variable does not promote confidence in the results of the final analysis.

Another issue with the credibility of this particular study was the timing of the different assessments. The student self-belief assessments were given at the beginning of the semester, and the final grade was used as the achievement measure. Bandura (1997) mentioned the necessity of measuring self-efficacy specifically and within a close time frame of the mathematics achievement measure. The authors specifically mention this limitation but explained that this microanalysis was not suitable for their particular research study on whether self-beliefs more generally predicted student achievement. This strategy, coupled with the fact that academic self-beliefs were measured together to produce the key finding that prior knowledge predicted student achievement over all other variables, makes this result seem less reliable.

The articles mentioned in this section of the literature review indicate the necessity of analyzing the mathematical self-efficacy of students based on the tenets established by Bandura (1997) through a known and calibrated assessment scale. When attention is not given to the tenets of the social cognitive theory, conflicting results can arise. Wadsworth, et al. (2007) determined that the mathematical self-efficacy of students within a traditional or online course was basically the same, but Spence and Usher (2007) found the mathematical self-efficacy of the students in the traditional course to be higher than those in the online course. Hailikari, et al. (2008) completely disregarded Bandura's warning of analyzing the construct within a close proximity of the assessment of the academic achievement variable, which creates a very unreliable conclusion that mathematical self-efficacy was not as influential as prior knowledge on mathematical achievement. The following section on the sources of mathematical self-efficacy continues this analysis based on the tenets of the social cognitive theory.

Sources of Mathematical Self-Efficacy

The four theorized sources of self-efficacy (mastery experience, vicarious experience, verbal and social persuasion, and physiological and emotional states) have been examined in many academic settings by a variety of methods. When trying to analyze the research on the sources of self-efficacy, the assessment tool and the particular source play an important role in the reliability of the study. The following part of the literature review focuses on evaluating and critiquing research studies with regards to each individual source of self-efficacy.

Mastery experience. Bandura (1997) posited that mastery experience was the strongest source of self-efficacy with regards to affecting a person's efficaciousness. Researchers (Lent, Brown, Gover, & Nijjer, 1996; Luzzo, Hasper, Albert, Bibby, & Martinelli Jr., 1999; Phelps, 2010; Stevens, Olivarez, Lan, & Tallent-Runnels, 2004) have confirmed that assertion through various means of analysis. More specifically, Stevens et al. (2004) analyzed mathematical self-efficacy on mathematics performance of Hispanic and Caucasian high school students. Their findings indicated that prior mathematics achievement was more influential for the Hispanic students rather than the Caucasian students. Their rationale for the statistically significant difference was that Caucasian students must mediate unsatisfactory prior mathematics experiences by the additional verbal persuasions of parents and teachers, as well as available role models. Since Hispanic students may not have those additional modes of self-efficacy active in their lives, their prior mathematics performance would be more influential. Their rationale was sound, but the manner in which prior mathematics achievement was measured did not correspond to the theoretical nature of the mastery experience self-efficacy construct. Having students provide their usual course average in mathematics courses did not account for how the grade affected their own assessment of their competence within the course.

Luzzo et al. (1999) conducted their study with four treatment conditions analyzed with pre- and post-test assessments of mathematics/science self-efficacy. The treatment groups consisted of participants taking a test of incomplete number series to enhance the performance or mastery experience source, the participants watching a 15-minute video of two successful graduates with similar backgrounds and stories to enhance the vicarious experience source, participants performing a combination of the two, and a control group with no intervention. The study determined that the performance accomplishment treatment had a statistically stronger impact on the participants than the videos of adult models. However, just viewing fifteen minutes of videos of successful strangers may not constitute the idea of a genuine role model with which to enhance self-efficacy through vicarious means. In addition to the treatment modes, the assessments occurred three times (pre-, post-, and immediately after the treatment) and the final two were only four weeks apart. This posed a test/retest threat to the internal validity of the study.

In an attempt to study the factors that inform the mathematical self-efficacy of students, Lent, Brown, Gover, & Nijjer (1996) had their participants answer questions on demographics, career aspirations and mathematics self-efficacy. The mathematics self-efficacy was evaluated by rating their confidence to obtain a B or better in various mathematics courses; however, this is not in line with the theoretical nature of self-efficacy. “Perceived self-efficacy is a judgment of capability to execute given types of performances; outcome expectations are judgments about the outcomes that are likely to flow from such performances” (Bandura, 2006, p. 309). The study also contained a qualitative component by asking the participants to do a thought-listing of the reasons for their confidence ratings. The researchers then categorized the various statements within the four theorized sources, as well as other emerging categories such as interest, effort, teacher quality, etc. Their analysis consisted of determining the percentage of comments per category. This study determined that personal performance (mastery experience) accounted for 58% of the responses. However, when focusing on the specifics of obtaining a B or better in a mathematics course, it is understandable that the responses related to confidence would fall more often within the performance category. Even though the qualitative nature of this study provides data that supports the methodological basis of the four sources of mathematical self-efficacy and retrieves the data in a manner that is underutilized within this specific field of the social cognitive theory, the types of questions in the written section may have lead to skewed responses towards performance criteria.

Not only has the mastery experience construct been analyzed within research studies by specific quantitative scales (Lent, Lopez, & Bieschke, 1991; Lent, Lopez, Brown, & Gore, 1996; Usher & Pajares, Sources of self-efficacy in mathematics: A validation study, 2009), other studies have used prior grades, successful completion of number series and a thought-listing analysis to provide evidence of the influence of the mastery experience source over the other sources. Even though the variety of methods corroborate Bandura's belief that mastery experience is the most influential source of self-efficacy, researchers must still analyze the construct in a manner consistent with the tenets of the theory.

Vicarious experience. Vicarious experience has consistently had a low to modest Cronbach alpha reliability coefficient value within research studies (Hodges & Murphy, 2009; Lent, Lopez, & Bieschke, 1991; Lent, Lopez, Brown, & Gore, 1996; Matsui,

Matsui, & Ohnishi, 1990). Usher and Pajares (2009) contend that the lower coefficient alphas may be caused by research studies focusing on only peer or adult models, but not both. However, some research studies (e.g., Hodges & Murphy, 2009; Zeldin & Pajares, 2000) found the vicarious experience construct to be most influential.

Even though Zeldin & Pajares (2000) focused their research on 15 women who were already involved in careers within the STEM (Science, Technology, Engineering and Mathematics) areas, this qualitative study seemed appropriate to include within this review. The interviews of the women revealed that their vicarious experiences and their verbal and social persuasions were highly influential in their success within the STEM career paths. Since the women were interviewed after establishing careers in the STEM areas, mastery experience, which is posited by Bandura (1997) to be the most influential source of information, may not be as relevant to them in retrospect. The grades and the academic accomplishments may fade over time; whereas, the personal connections and encouragement may grow stronger.

The sample of women was purposive for this study and had to meet the requirements selected by the researchers. Each interview consisted of the same nine questions and was recorded and transcribed verbatim. The researchers explained how they tried to account for internal validity by having other colleagues with familiarity of educational issues, but not self-efficacy theory, read through the transcripts and determine if other themes emerged from the data.

The women in the study noted teachers who had been influential in their academic pursuits of careers in STEM areas. These women also discussed academic resiliency as it related to how they continued to pursue their majors in college and their careers upon graduating when obstacles would try to deter them. The purposeful sample and the small sample size did not allow for generalizability. However, being able to interview these women after navigating through the academic world and emerging with a career in a STEM area provided additional insight into how self-efficacy could play a significant role in not only academic achievement but also within academic and life-long success.

Hodges & Murphy (2009) conducted a study to explore the sources of self-efficacy of students enrolled in a technology-intensive asynchronous college algebra course. The Sources of Mathematics Self-Efficacy (SMSE) scale developed by Lent et al. (1991) was used to determine the scores for the four theoretical sources, which were used as predictor variables within the study. The dependent variable was the Self-Efficacy for Learning Mathematics Asynchronously survey developed by Hodges (2008). The regression analysis showed that vicarious experiences and physiological/affective states were the only two statistically significant predictors. It seems reasonable that how a student feels throughout the duration of taking an asynchronous course would have a significant impact on how efficacious he/she is about learning in an asynchronous environment. Additionally, learning in a non-traditional environment could be influenced by the successes of other students who have taken similar courses asynchronously. Since the dependent variable pertains to the self-efficacy of learning mathematics asynchronously, which usually indicates an online course, and the data was collected using an online survey, the reliability of the results may be questionable. Students who feel less efficacious about taking an asynchronous course may not feel efficacious about taking an online survey.

Since the vicarious experience construct has had low to modest Cronbach's alpha reliability coefficients in research studies , (Hodges & Murphy, 2009; Lent, Lopez, & Bieschke, 1991; Lent, Lopez, Brown, & Gore, 1996; Matsui, Matsui, & Ohnishi, 1990) it is important to determine a way of assessing this source of mathematical self-efficacy that will not only be consistent with the tenets of the theory but also will provide a more consistent measure. Zeldin and Pajares (2000) were able to obtain results of the influential impact of the vicarious experience construct on the women in their study through an interview process. Qualitative studies may provide a more informative measure of this construct because it does not restrict the role models to only adults, peers, or teachers. Students are influenced by other role models in society as well, but the research on the sources of self-efficacy does not usually include those options.

Verbal and social persuasion. Verbal and social persuasion has been studied by researchers focused on encouragement by teachers, parents and friends (Hodges & Murphy, 2009; Lent, Lopez, Brown, & Gore, 1996; Matsui, Matsui, & Ohnishi, 1990). Encouraging statements were extremely evident in the stories told by the women with careers in STEM areas in the qualitative study by Zeldin & Pajares (2000). The encouragement was described with regards to not only mathematics but also a confidence that others believed they could succeed in anything. Those encouraging words strengthened their confidence and the resiliency to overcome any obstacle. However, the knowledge and credibility of the other person makes a difference in the level of influence of this source of self-efficacy (Bandura, 1997). Since the items used to analyze this particular source deal mainly with the encouragement of teachers, parents, and peers, researchers have yet to analyze the persuasiveness of the message sent by communities, public figures, media, or society as a whole (Usher & Pajares, 2008).

Physiological and emotional states. The physiological and emotional states have been assessed in many mathematical research studies as anxiety (Hodges & Murphy, 2009; Lent, Lopez, & Bieschke, 1991; Lent, Lopez, Brown, & Gore, 1996), because all of the instruments were using variations of the Fennema-Sherman Math Anxiety Scale as revised by Betz (1978). Other researchers (Matsui et al., 1990; Zeldin & Pajares, 2000) asked students to assess this construct by thinking of how mathematics made them feel. In the thought-listing analysis by Lent, Brown, Gover, and Nijjer (1996), responses were categorized within this construct based on statements of fear, such as “math frightens me.” However, it was only responsible for 9% of the responses mentioned by the participants. As mentioned earlier, Hodges and Murphy (2009) found physiological states and vicarious experiences were the only two sources that could statistically significantly predict the self-efficacy of learning mathematics asynchronously. Usher & Pajares (2009) contend that “[a]lthough one’s feelings of anxiety may be the most salient form of psychological arousal in the classroom, particularly in the domain of mathematics, a measure that includes other forms such as physical arousal and mood would be more faithful to Bandura’s (1997) description of this source” (p. 91).

Conclusion

Hall and Ponton (2005) suggested that educators have a tendency to teach the same way with different courses without recognizing the impact it may have on students with varying levels of self-efficacy. The level of self-efficacy determines the effort students are willing to put into tasks they find difficult and the resiliency they have in the face of setbacks resulting from those difficult tasks (Bandura, 1997). Thus, teachers of developmental courses, and more specifically freshmen courses, may want to consider the self-efficacy of students within their courses. They should strive to create a learning environment enabling their students to not only master the mathematics concepts during this transitional year of college, but also to produce students who will become lifelong learners (Hall & Ponton, 2005).

The studies in this literature review exemplify the various ways in which self-efficacy and the sources of self-efficacy are measured and how probable it is that research studies could provide conflicting results. Additionally, the measures for self-efficacy need to take into consideration the specificity of the self-efficacy construct when related to specific domains, such as mathematics, and adhere to the suggestions posited by Bandura (1997) when measuring the effects of self-efficacy with the domain specific performance (Usher & Pajares, 2008). Similarly, more research needs to be done on the collegiate level utilizing consistent and calibrated measures appropriately studied in relation to the sources of mathematical self-efficacy.

The lack of current research on the impact of self-efficacy on collegiate mathematics achievement opens the door for future investigations within areas of ethnicity and self-efficacy enhancing interventions (Schunk & Pajares, 2002). As the qualitative research article (Zeldin & Pajares, 2000) showed a connection between vicarious experiences and verbal and social persuasions with females who chose careers within the STEM areas, more research should be done to investigate the sources of self-efficacy among other subgroups defined by race, gender, and possibly rural and urban populations (Usher & Pajares, 2008). Additionally, self-efficacy research related to non-traditional students on the collegiate level needs to be done, especially since research, according to Cassazza (as cited in Hall & Ponton, 2005), has shown it to be the fastest growing segment within higher education. Research in these areas will not only add to the knowledge base regarding self-efficacy and the sources of mathematical self-efficacy, but also may provide insight into the types of interventions that would be successful and the areas where those interventions can be applied.

Chapter III: Methodology

This chapter describes the methodology used for the descriptive, survey research study. The purpose of this study was to determine which student characteristics (race, gender, sexual orientation and hometown location) influence the sources of mathematical self-efficacy of college freshmen, if any. First, the research design section will define the type of research design, the population and sample, the instrument, and the procedures used for the study. Second, the data analysis section will define all the variables used in the study, as well as describe the statistical analysis process of the study. Finally, the validity section focuses on the reliability and validity of the instruments, as well as the research study as a whole.

Research Design

A descriptive, survey research design was chosen to investigate the four sources of mathematical self-efficacy of college freshmen. More specifically it addressed the following research question: What student characteristics influence the four sources of mathematical self-efficacy, if any?

Population and sample. The target population for this study was college freshmen attending small, private, not-for-profit, 4-year universities. The sample universities were selected using an online filtering process of the Carnegie Foundation Classifications of colleges and universities (Carnegie Foundation). The Carnegie Commission on Higher Education developed a classification of colleges and universities in 1970. The original publication was in 1973 with updates several times over the years and more recently in 2010. Utilizing the custom listings link on the website, several options were selected to create the custom list of colleges and universities for this study (see Appendix A for the complete list of categories and selected options). The selections were made based on the focus of the research study, which pertained to undergraduates of small, four-year institutions. The selection process resulted in 37 institutions, but seven were eliminated right away by requiring not-for-profit, four-year or above institutions.

Since 30 institutions were out of the scope of this research study based on time and resources, the list was processed identically except for selecting only the Very Small institutions. Of the nine universities produced by this selection process, all but three were classified as professions plus arts and sciences with some graduate coexistence. So, those three were eliminated and the remaining six form the target sample used for this research study. (See Appendix A.)

In January 2012 an email was sent to the Dean of Academic Affairs (or comparable position) of each of the six institutions selected through the Carnegie Foundation classifications process mentioned above. One of the institutions chose not to participate based on a policy within the Registrar's Office. Two of the institutions made no attempt to communicate with the researcher even after several attempts. After the researcher provided the appropriate information for each of their IRB processes, three of the original six institutions agreed to participate in the study. Since each of the three institutions had some type of religious affiliation, the generalizability of the data to the population may be limited.

All freshmen students enrolled at each participating university in the spring semester of 2012 were chosen to take part in the study. A contact person at each of the sample institutions used their database to produce the list of all freshmen students over the age of 17 (per IRB regulations), including email addresses, and provided the list to the researcher for this study. A total of 474 freshmen students were identified as the target population. Each of the 474 freshmen students were sent an email (see Appendix B) containing a brief description of the research study and its importance to the education community, a link containing written acknowledgement of their rights and assurance of privacy regarding their information, and a link to the online survey (see Appendix C) for this research study. Submitting the online survey constituted their consent to participate in the study.

Instrumentation. The sources of mathematical self-efficacy have been analyzed by various means as outlined in the review of literature chapter of this study. However, four specific scales (Lent, Lopez, & Bieschke, 1991; Matsui, Matsui, & Ohnishi, 1990; Ozyurek, 2005; Usher & Pajares, 2009) have been developed and used more consistently within the research. Since this research study focused on analyzing the influence of student characteristics on the four theorized sources of mathematical self-efficacy, it was important to select an instrument that closely aligned with theory and had been validated in other research studies.

Matsui, Matsui, and Ohnishi (1990) developed their scale for the sources of mathematical self-efficacy using the self-reported grades of the students as their mastery experience score. However, this does not correspond with the theoretical nature of Bandura's mastery experience construct. "Mastery experience" refers to the manner in which an individual cognitively processes previous successes and failures. When students only report their grades, it does not analyze how the grade affected their competence in mathematics. Since one student may view a *C* in a course as good and another could view it as bad, then their grades would not be an accurate indicator of their level of self-efficacy (Usher & Pajares, 2009),

Ozyurek (2005) developed a measurement for the sources of mathematics-related self-efficacy referred to as Math-inform. The Math-inform consisted of only three sources of self-efficacy, because the first factor contained items related to both mastery experience and social persuasion. It was not apparent as to why those two constructs were combined, as they are theorized by Bandura to represent completely different constructs. Additionally, the instrument used a 4-point Likert scale, which is not sensitive enough to account for the nuances within cognitive processing (Bandura, 2006).

Lent, Lopez and Bieschke (1991) developed a scale to analyze the four sources of mathematical self-efficacy of college students. The 40-item instrument was divided into ten questions per source. All of the sets of questions were designed by them, except for the questions pertaining to the physiological and emotional states. They used the Fennema-Sherman Math Anxiety Scale revised by Betz (1978) to analyze that particular construct. Even though their instrument is more theoretically aligned than the previous two, the 5-point Likert scale is still not sensitive enough according to Bandura (2006).

Usher and Pajares (2009) developed the Sources of Middle School Mathematics Self-Efficacy Scale through a 3-phase process. The first phase began with a 6^{th} grade focus group to determine the understandability of the wording of the instrument. It was then used during a research study of 1111 middle school students. After conducting an analysis with the first scale, modifications were made and, during phase two, it was presented to 824 middle school students. More analysis resulted in more modifications. Before the instrument was used again during the third phase, the authors submitted their items to experts within the social cognitive theory field (Bandura, Zimmerman, and Schunk) for feedback. Based on the feedback from the experts more modifications were made, which resulted in an instrument containing 73 items at the beginning of the final phase. However, through revisions based on various types of analysis during the final phase, the official Sources of Middle School Mathematics Self-Efficacy Scale has 24 items consisting of six items per source. Each of the source sections had Cronbach's alpha reliability coefficients above 0.80 indicating that over 80% of the variance in the total score for each source of mathematical self-efficacy is shared within the six specific items on the scale (Warner, 2008). More specifically, the Cronbach's alpha coefficients for each source was 0.88 for mastery experience, 0.84 for vicarious experience, 0.88 for social persuasions, and 0.87 for physiological state (Usher & Pajares, 2009).

"Comparing the correlation between the sources measures and self-efficacy outcomes to those obtained in previous research studies of the sources reveals that the measures created in this study are not only sound, but demonstrate greater predictive utility than have past measures" (Usher & Pajares, 2009, p. 97). For this reason, as well as the desire to use a valid and calibrated instrument to help further the research on the sources of mathematics self-efficacy, the Sources of Middle School Mathematics Self-Efficacy Scale was chosen for this research study. It was adapted to be used with college-level freshmen students (see Appendix C) by making two cosmetic changes:

Question #2 – Seeing *kids* do better than me in math helps me do better in math.

(*kids* was replaced by *students.*)

Question #10 – I got good grades *on my last report card*.

(*on my last report* card was replaced by *in my last math class.*)

The Sources of Middle School Mathematics Self-Efficacy Scale used a six-point Likert scale designed for middle school students where the choices were **F** – Definitely False, **F** – Mostly False, F – A little bit False, T – A little bit True, **T** – Mostly True, and **T** – Definitely True. The researcher choose to use the exact same Likert scale for this research study, because the choice of *false* and *true* seemed more appropriate for the items in the scale than the standard *agree* and *disagree*. The Likert scale was converted to a number from 1 to 6, with 1 representing *Definitely False* and 6 representing *Definitely True*.

Pilot study. A pilot study of 20 upperclassmen at a small, liberal arts institution in Virginia was conducted in January 2012 to test the instrument for the research study and to make any necessary adjustments to the instrument and/or the instructions of the instrument. Based on the results of the pilot study, it was evident that students were having trouble inputting their high school and college GPA. Changes in the demographic section of the survey were made to accommodate this situation. Instead of asking students to input their GPA specifically, they were asked to select the radio button that aligned with their GPA (see Appendix C). Even though this changed the nature of the variable from a continuous to discrete variable, the researcher believed it was more important to have those two data items available for analysis than risk losing out on the information altogether.

Procedures. In the spring of 2012**,** all of the college freshmen students (474) in the three universities were asked to participate in the research study through an email describing the study and its importance to the educational community. The email (see Appendix B) contained two Internet links: 1) a website that provided all of the background information and IRB required information and 2) the demographic questionnaire with the 24 - item survey instrument that was adapted for this particular research study for college students from Usher and Pajares' (2009) Sources of Middle School Mathematics Self-Efficacy Scale. The researcher chose to include the official IRB required information on a separate website rather than within the email sent directly to the students, because many students may not participate if they had to read through a lengthy document to get to the actual survey link. The researcher used www.weebly.com to design the informational website specifically for this research study.

The survey was created by the researcher using www.snapsurveys.com. This particular survey website was chosen by the researcher for several reasons: 1) her employer had an account with this company, 2) the use of the software was of no cost to the researcher, and 3) the institutional researcher at her place of employment could provide support to questions that may arise in the process of creating the survey document. Students had access to the survey for three weeks before it was closed and all of the data were transferred to an Excel file and then to a SPSS data file. The researcher sent follow-up emails each week to thank those who had already participated in the survey and to politely encourage others to participate.

Students were given an incentive to participate in the research study. The researcher promised to include the participants in two random drawings for a $50 e-gift card. Since students responses to the survey were not associated with their email addresses, the researcher had to include a final question on the survey instrument asking the student to provide an email address if they wanted to be included in the drawing. When the survey was closed the email addresses provided by the participants were immediately separated from the other information and stored in a separate Excel file. The remaining data was used throughout this research study with no link to any of the participants. Only 79 students provided their email addresses for the random drawing. Using a random number generator, the researcher obtained 62 and 34 as the two winners of the $50 e-gift cards. The researcher sent an email to the participants associated with those email addresses to thank them again for their participation and to inform them of their winnings. Since the researcher allowed the students to submit their responses anonymously, it was not possible to identify the participants based on their institution.

Data Analysis

Measures. The following list contains the variables used for this study.

Dependent Variables

Mastery Experience (ME)

Vicarious Experience (VE)

Verbal and Social Persuasions (VSP)

Physiological and Emotional States (PES)

Vicarious Experience – Adult models (VEadult)

Vicarious Experience – Peer models (VEpeer)

Vicarious Experience – Self model (VEself)

Independent Variables

Gender (Gender) – Two levels (Male and Female)

Race (Race) – Three levels (African American, Caucasian, and Other)

Sexual Orientation (SexOr) – Three levels (Bisexual, Heterosexual, and Homosexual)

Hometown Location (Home) – Three levels (Rural, Suburban, and Urban)

High School GPA (HSGPA) – Six levels based on grade intervals

College GPA (COLGPA) – Six levels based on grade intervals

Class Grade (grade) – Seven levels based on letter grade received in math class taken previous semester

Statistical analysis. The purpose of this research study was to identify the student characteristics (if any) that might causally influence a student's score on each of the four sources of mathematical self-efficacy. In other words, the researcher wanted to determine how much variability existed in the means of the sources of mathematical self-efficacy across groups of students (i.e. African American students, Female students, cross-sections of students, etc.). Huck (2000) contends that analysis of variance (ANOVA) ranks first in popularity for applied researchers when comparing three or more means. However, the researcher had to determine which type of ANOVA (one-way, factorial, or multivariate) was appropriate based on the research question and the data collected.

A one-way ANOVA (also referred to as ANOVA) would determine whether there are mean differences in the scores of one of the sources of mathematical self-efficacy based on the groups defined by one of the independent variables (Warner, 2008). In other words, an ANOVA would determine whether the groups formed by gender (male and female) had statistically significant mean differences on the mastery experience dependent variable. This analysis would be performed in SPSS by selecting ANALYSIS – COMPARE MEANS – ONE WAY ANOVA.

The purpose of a factorial ANOVA would be "to study the independent and simultaneous effects of two or more independent variables on an outcome" (Cresswell, 2008, p. 315). In other words, a factorial ANOVA would determine whether the combination of gender and race (African American females, Caucasian males, etc.) interact to create statistically significant mean differences on the mastery experience dependent variable. This analysis would be performed in SPSS by selecting ANALYSIS – GENERAL LINEAR MODELS – UNIVARIATE.

The purpose of a multivariate analysis of variance (MANOVA) would be to determine whether groups formed by two or more independent variables had statistically significant mean differences on multiple dependent variables (Warner, 2008). Warner (2008) goes on to state that the null hypothesis of a MANOVA would correspond with “the assumption that when the scores on all *p* of the Y outcome variables are considered jointly as a set, taking intercorrelations among the Y variables into account, the means for this set of *p* outcome variables do not differ across any of the populations that correspond to groups in the study” (Warner, 2008, p. 702). In other words, a MANOVA would determine whether the combination of the independent variables interact to create statistically significant mean differences on the dependent variables taking intercorrelations into account. This analysis would be performed in SPSS by selecting ANALYSIS – GENERAL LINEAR MODELS – MULTIVARIATE.

The researcher chose to begin the analysis by performing a MANOVA using all of the independent and dependent variables to determine if there were any statistically significant differences in the four sources of mathematical self-efficacy taking their intercorrelations into account. Once the MANOVA was not found to have any statistically significant results and since, the four theorized sources of mathematical self-efficacy address distinct sources of information (Lent, Lopez, Brown, & Gore, 1996), which can be analyzed separately, the researcher chose to perform factorial ANOVAs for each of the dependent variables. Furthermore, a Confirmatory Factor Analysis (CFA) was conducted to test whether the questions contained within the survey were still corresponding to the source they were intending to analyze. The CFA was conducted using the AMOS 20 program. All other analyses were conducted using SPSS 20.

Validity

Threats to the reliability and validity of the survey instrument are possible, but measures were taken to reduce that possibility. Only two minor changes were made to the Usher & Pajares' (2009) survey (see Appendix C) to make it more appropriate for college-age students. The changes were cosmetic so it was doubtful that it would have affected the validity of the survey instrument. Threats to reliability, however, are higher because of the low response rates of the participants.

Out of the 474 emails sent to the freshmen students at the three participating institutions, 106, or 22.3%, responded. The small sample size and low response rate can result in a response bias where "the responses do not accurately reflect the views of the sample and the population" (Cresswell, 2008, p. 403). By comparing the combined statistical data (National Center for Education Statistics, 2011) of the three institutions participating in the research study (11.9% African American, 65.9% Caucasian, 22.2% other races, 57.8% females and 42.2% males) with the combined statistical data of the sample (22.6% African American, 61% Caucasian, 16% other races, 50% females and 50% males), the data appears to be comparable with the exception of a higher percentage of males and African American participants than would be reasonably expected.

Since the researcher works at one of the participating institutions with a larger percentage of students within those two demographic areas, it is probable that her name was known to the participants and generated more participation from that institution and specifically those demographic groups. However, all participating students were informed that their responses would not be known to the researcher, which lessens the possibility of response bias. Additionally, the responses of the participants were analyzed as one whole group without breaking down the analysis per institution, which would also lessen the issues with reliability. However, since the researcher does not know what percentage of the students attended each of the three institutions, then the overall results may be unintentionally skewed. Even though the researcher took every opportunity to make sure the data collected did not have issues with reliability and validity, they are not completely negated. This combined with the small sample size will limit the generalizability of the results.

Chapter IV: Results and Analysis

The purpose of this descriptive, survey research study was to determine which student characteristics (race, gender, sexual orientation and hometown location) influence the sources of mathematical self-efficacy of college freshmen, if any. In order to assess whether the four sources of mathematical self-efficacy were influenced by different student characteristics, several types of analyses were conducted (CFA, factorial ANOVAs, and one-way ANOVAs), based on the type of data provided, using either SPSS 20 or Amos 20. The in-depth discussion of the results will follow the description of how missing data were addressed, the discussion of the sample demographics, and how data screening was processed.

Missing Data

A total of 106 students responded to the email and submitted their responses to the Sources of Middle School Mathematics Self-Efficacy Scale revised for college freshmen. After analyzing the data more closely, four of the participants submitted a response that did not answer over half of the questions on the sources of mathematical self-efficacy scale. Even though the sample size is already small, it was appropriate to eliminate those additional four participants from the overall analysis; thus, reducing the sample size to 102 participants. Once those four participants were eliminated, the amount of data missing was minimal (1.1%) and randomly scattered throughout the data field.

Since each student's score on one of the four sources of self-efficacy was the mean average of the six questions that specifically pertained to that particular source, the researcher chose to replace any missing question response with the mean average of the remaining questions that pertained to the same source of self-efficacy (Warner, 2008).

Therefore, the missing data did not significantly impact the overall score of the source of mathematical self-efficacy per student. Additionally, during the process of performing the statistical analysis using SPSS, *pairwise* deletion was chosen over *listwise* deletion due to the small sample size and the need to include as much data as possible within each analysis.

Demographics

The 102 freshmen in the study are categorized by the following demographics: 49% female, 51% male, 22.5% African American, 62.7% Caucasian, 14.7% other race, 88.2 % heterosexual, 2.9% bisexual, 3.9% homosexual, 39.2% rural hometowns, 27.5% urban hometowns, and 33.3% suburban hometowns. Unfortunately, the data collected from the participants regarding sexual orientation (see Figure 4.1) did not provide enough difference within the sample to allow for this particular characteristic to be used within any of the analyses.

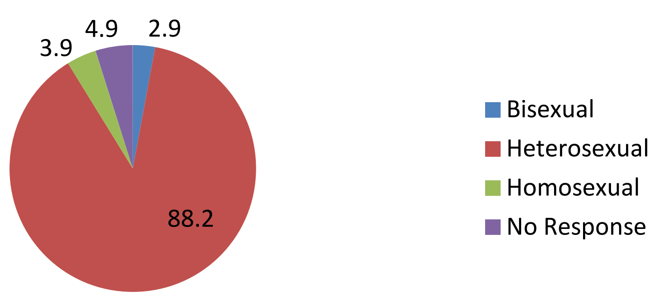

Figure 4.1 *Sexual Orientation Demographics*

Data Screening

Once the missing data were addressed as mentioned above, each of the other variables were investigated for outliers and abnormalities. The high school and college GPA contained data that needed to be reclassified. The original GPA questions provided the students with six ranges for GPA (1: Below 2.00, 2: 2.00 – 2.49, 3: 2.50 – 2.99, 4:

3.00 – 3.49, 5: 3.50 – 3.99, 6: 4.00 or above) from which to select their appropriate GPA. The high school GPA (HSGPA) did not have any student in Level 1, only 5 in Level 2, and only 8 in Level 6 (see Figure 4.2). The college GPA (COLGPA) had only 6 in Level 1 and 3 in Level 6 (see Figure 4.3).

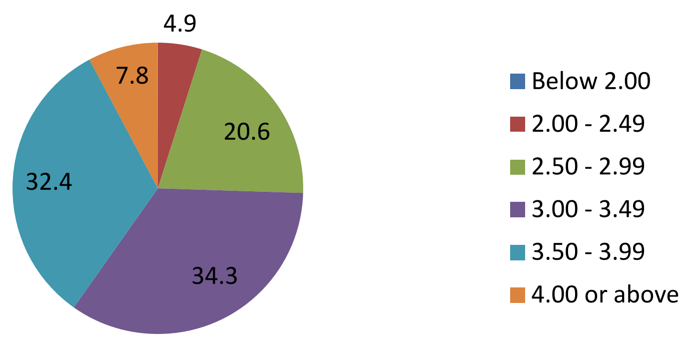

Figure 4.2 *High School GPA Demographics (HSGPA)*

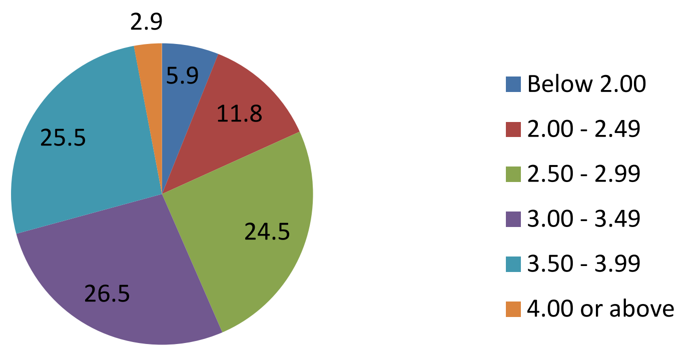

Figure 4.3 *College GPA Demographics (COLGPA)*

Both the high school GPA and the college GPA were reclassified to treat the outliers and to make the different levels more equal based on the number of students within each level. For the high school GPA the old Levels 1, 2 and 3 became the new high school GPA (HSGPA2) Level 1 (Below 3.00), the old Level 4 became the new

Level 2 (3.00 – 3.49), and the old Levels 5 and 6 became the new Level 3 (3.50 or above) (see Figure 4.4). For the college GPA the old Levels 1 and 2 became the new college GPA (COLGPA2) Level 1 (Below 2.50), the old Level 3 became the new Level 2 (2.50 – 2.99), the old Level 4 became the new Level 3 (3.00 – 3.49), and the old Levels 5 and 6 became the new Level 4 (3.50 or above) (see Figure 4.5).

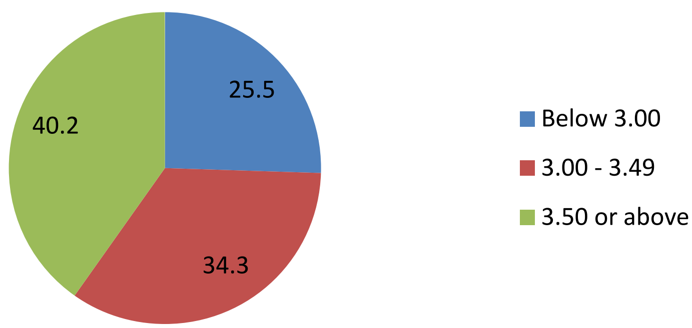

Figure 4.4 *High School GPA Demographics Reorganized (HSGPA2)*

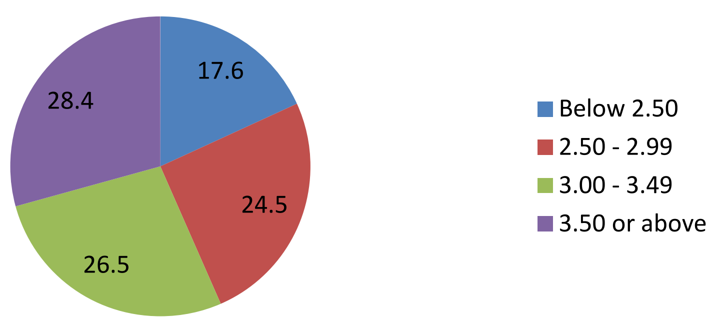

Figure 4.5 *College GPA Demographics Reorganized (COLGPA2)*

Out of the 73 freshmen who took a math class last semester (fall 2011), three withdrew from the course. Since some institutions use an E instead of F to signify a “not passing” grade, it was included as an option for the course grade; however, no student received a letter grade of E. Additionally, the numbers of students obtaining a D or F were small compared to the other letter grades. In order to make the levels of the variable more equal, to address any outliers or abnormalities, and to associate a higher letter grade with a higher number value (comparable to a standard GPA score), the variable was reclassified as *classgrd* with the following levels: Level 4 – A grade, Level 3 – B grade, Level 2 – C grade, Level 1 – D or F grade. The students who withdrew from the course were eliminated from the new variable, which leaves *classgrd* with a total of 70 students (see Figure 4.6).

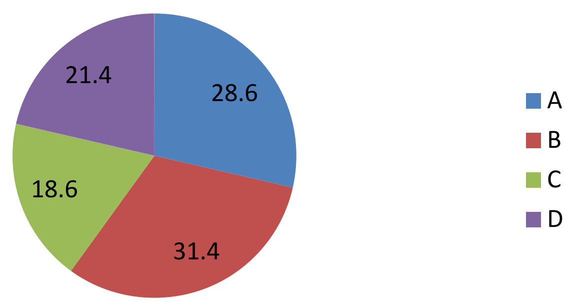

Figure 4.6 *Letter grade received in math course taken the previous semester (classgrd)*

The sources of mathematical self-efficacy were calculated at this time by averaging the values of the participants' responses on the six questions pertaining to each source (see Appendix C). Seven of the questions were reversed coded (marked with an asterisk) to correspond a higher value with a higher sense of self-efficacy based on that particular source. The reverse coding matched the coding of the questions from the study by Usher and Pajares (2009). Mastery experience (ME) was calculated using questions 1, 4, 9*, 10, 13, and 19. Vicarious Experience (VE) was calculated using questions 2, 14, 17, 20, 22, and 24. Verbal and Social Persuasions (VSP) were calculated using questions 6, 8, 11, 16, 18, and 23. Physiological and Emotional States (PES) were calculated using questions 3*, 5*, 7*, 12*, 15*, and 21*. The more stressed, anxious or depressed a student felt regarding mathematics, the lower the score. Students who felt good about the mathematics course would have a higher physiological and emotional states score than those who felt bad.

In order to assess whether combining the scores of the particular questions for all participants in the research study provide a stable and internally consistent measure (Warner, 2008), the Cronbach's alpha reliability coefficient was calculated for each source of mathematical self-efficacy: 0.89 for mastery experience, 0.75 for vicarious experience, 0.94 for verbal and social persuasions, and 0.90 for physiological and emotional state. The Cronbach's alpha coefficient was higher in this study for mastery experience, verbal and social persuasions and physiological and emotional states than Usher and Pajares' (2009) original study (0.88, 0.88, and 0.87, respectively), but lower than their vicarious experience Cronbach's alpha coefficient (0.84). Usher and Pajares (2009) have acknowledged that a low Cronbach's alpha coefficient has been an issue with this particular construct in the past; however, it was still higher in this research study than other studies (Hodges & Murphy, 2009; Lent, Lopez, & Bieschke, 1991; Matsui, Matsui, & Ohnishi, 1990).

Usher and Pajares (2009) contend that the low Cronbach's alpha reliability coefficient of the vicarious experience construct may be a result of research studies focusing on either peer role models or adult role models, but not both. Within their study the vicarious experience construct was separated into three subcategories based on the type of role model: adult, peer and self. Vicarious experience – adult refers to the average of questions 14 and 24. Vicarious experience – peer refers to the average of questions 2 and 20. Vicarious experience – self refers to the average of questions 17 and 22. Since the

Cronbach’s alpha reliability coefficient was lower in this study than Usher and Pajares’ (2009), the Cronbach’s alpha reliability coefficient was analyzed on the three subcategories as well. The Cronbach’s alpha coefficient of reliability was lower for each of the subsections of the vicarious experience construct (VEadult: $\alpha = 0.52$, VEpeer: $\alpha = 0.51$, and VEself: $\alpha = 0.62$), which implied that all independent items within each subsection are necessary for the overall reliability of vicarious experience.

After verifying the internal consistency reliability for each of the sources (ME: $\alpha = 0.89$, VE: $\alpha = 0.75$, VSP: $\alpha = 0.94$, and PES: $\alpha = 0.90$) based on the four groups of six questions, it was important to determine whether the responses to those questions were still corresponding to their specified latent variable as established by Usher and Pajares (2009) through confirmatory factor analysis (CFA).

Confirmatory Factor Analysis

Thomas Schmitt (2011) provided an overview of the various methods available to researchers interested in performing factor analysis: exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). According to Schmitt, maximum likelihood (ML) is one of the most commonly used statistical estimation methods. ML requires at least 5 participants per item, which would mean at least 120 participants for the 24-item survey used in this research study, to establish a higher level of reliability per item. Additionally, ML requires continuous, normally distributed data, which is not found on survey questionnaires with a Likert scale, such as the one used in this study. Even though the researcher conducted the ML analysis to verify the issues related to using the analysis on ordinal data, such as excessive multivariate kurtosis, the results are not included within this study. Figure 4.7 presents only the model designed for the ML analysis.

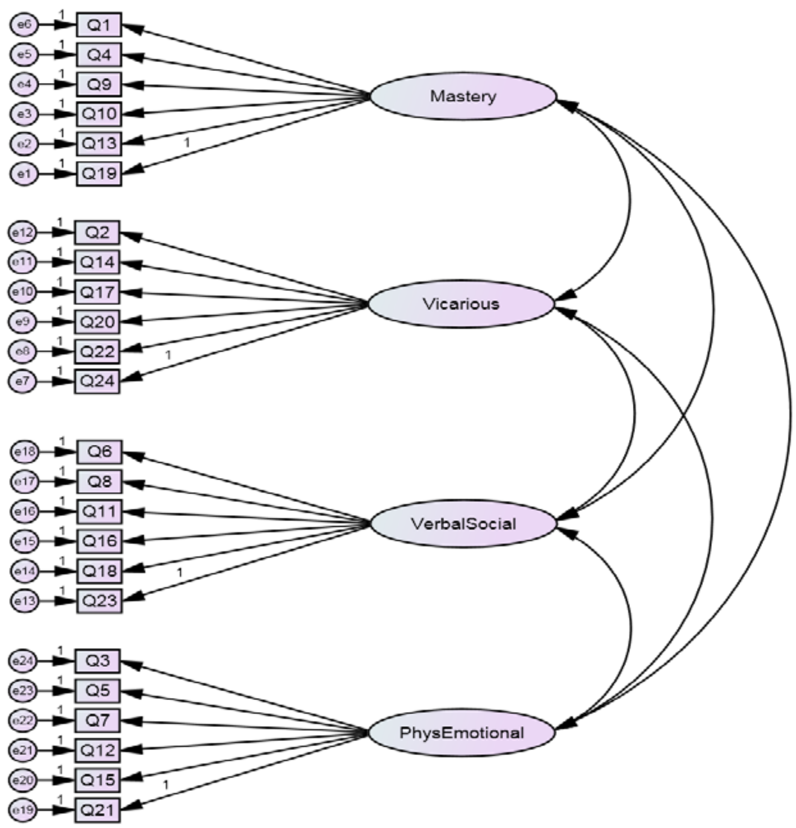

Figure 4.7 *Confirmatory Factor Analysis Model for Maximum Likelihood and Bayesian estimation of the twenty four survey questions*

Additionally, Schmitt (2011) provides robust least squares (LS), robust weighted least squares (WLS) and Bayesian estimation as the alternative CFA approaches for ordinal data with two to five categories. Muthen & Asparouhov (2010) proposes applying the Bayesian approach to factor analysis and structural equation modeling (SEM) because "current analyses using maximum likelihood (ML) and likelihood-ratio χ^2 testing apply unnecessarily strict models to represent hypotheses derived from substantive theory" (p. 3). In other words, theoretically-based models are often rejected based on the restrictive limitations of the ML approach (i.e. large sample size of at least 5 participants per item, normal distributions). Thus, Bayesian estimation was chosen as the alternative method for this research study because it does not require normally distributed, continuous data from large sample sizes.

Bayesian estimation has not been used widely in social-psychological research even though it has been around since the 18th century (Arbuckle, 2007; Byrne, 2009). One reason for its limited appeal to researchers outside of the statistical field may be that Bayesian analysis appears to be difficult to perform (Muthen & Asparouhov, 2010) and the computational software to perform the analysis have been unavailable (Arbuckle, 2007).

In the Bayesian approach any quantity that is unknown, such as the four sources of self-efficacy, is viewed as a random variable and assigned a joint probability distribution (Arbuckle, 2007). This distribution combines what is known about a particular parameter, called the prior distribution, with the data-based evidence by the well-known Bayes' Theorem, which results in an updated distribution known as the posterior distribution (Arbuckle, 2007). In other words, the prior distribution would be based on prior studies or substantive theory, such as the model developed by Usher & Pajares (2009) and used for this research study (see the model in Figure 4.7). The data-based evidence is the responses of the students to the 24-item questionnaire. The Bayesian analysis will determine a posterior distribution and a posterior predictive p-value (PPP) of model fit, where the range of the p-value is between 0 and 1 with a p-value around 0.5 indicating an excellent fit (Muthen & Asparouhov, 2010). "Model testing is carried out using posterior predictive checking which is found to be less sensitive than likelihood-ratio χ^2 testing to ignorable degrees of model misspecification" (Muthen & Asparouhov, 2010, p. 3).

Using AMOS 20, the Bayesian approach was applied to this research study yielding a posterior predictive p-value of 0.50, DIC = 3159.84, and effective number of parameters = 73.37, which means it was an excellent fit. Once the model fit was established, the research study continued with an analysis of the results of the survey items.

Data Analysis

Descriptive statistics. Before data analysis of the survey items began, the descriptive statistics of the four sources of mathematical self-efficacy and the three subcategories of vicarious experience were calculated (see Table 4.1). Since the absolute value of the skewness and kurtosis of each dependent variable was less than 1, the data was considered normally distributed and parametric tests were used for the analysis.

Table 4.1

Descriptive statistics for the seven dependent variables

	Mean	SD	Variance	Skewness	Kurtosis
Mastery Experience	4.110	1.185	1.405	-.516	-.398
Vicarious Experience	3.804	.966	.934	-.014	-.554
Verbal & Social Persuasions	3.564	1.404	1.972	-.093	-.899
Physiological & Emotional States	4.050	1.250	1.564	-.366	-.534
Vicarious Experience – Adult	3.971	1.128	1.271	-.427	.055
Vicarious Experience – Peer	3.765	1.183	1.400	-.321	-.263
Vicarious Experience – Self	3.691	1.305	1.703	-.061	-.783

Effect sizes, power, and Type I error value. Several different effect size indexes (Cohen's *d*, eta squared (η^2), partial-eta squared, and R^2) are used within research studies to estimate the proportion of the variance in the scores of the dependent variable based on the independent variables (Warner, 2008). When the researcher performed the factorial ANOVAs in SPSS, the output generated the R^2 and partial-eta squared effect sizes. The R^2 effect size provides the proportion of variance based on the combination of all of the independent variables and can be used as an index of the strength of a linear relationship (Warner, 2008), which would be more appropriate for regression analysis or multivariate analysis of variance. The partial-eta squared effect size provides the proportion of the remaining variance in the scores of the sources of mathematical self-efficacy when the other independent variables and their interactions have been removed (Warner, 2008). The researcher chose to include the partial-eta squared effect size in the factorial ANOVA tables in this research study, because it would provide the amount of variance within the means associated with each individual independent variable when all of the other variables were held constant.

Additionally, the researcher chose to include the η^2 effect size also within the analysis of this research study, because it can be used to analyze the statistical power of the results. "Statistical power is the probability of obtaining a test statistic large enough to reject H_0 when H_0 is false" (Warner, 2008). Generally, researchers would like to obtain 80% statistical power. Cohen (as cited in Warner, 2008) established a table to determine the statistical power from the effect size. Cohen established three levels of effect based on the *d*-value (*d*=.20, small; *d*=.50, medium; and *d*=.80, large) and also provided the corresponding η^2 values (.010, .059, and .138, respectively) (Warner, 2008). Warner

(2008) also presents Cohen's table that provides the sample size necessary to obtain the desired statistical power based on the value of η^2. Since the η^2 effect size was not part of the factorial ANOVA results, the researcher calculated the effect size for each variable by dividing the sum of squared deviations of the scores of the individual variable based on the mean of that variable by the sum of squared deviations of all of the scores based on the overall model (i.e. SS_A/SS_{Total}) (Warner, 2008).

Additionally, the researcher had to determine what percentage of error would be allowed within the study. Since Cohen's statistical power table (as cited by Warner, 2008) was based on the researcher using the standard $\alpha = .05$, two-tailed criterion for significance, the researcher chose to select $\alpha = .05$ as the desired Type I error risk for the entire study. In other words, there is a 5% chance that the mean differences found, if any, between the groups of students would not occur naturally within the population of the students. Furthermore, when multiple hypothesis testing procedures are used on the same dependent variable within a study, an adjustment must be made to account for the increased risk of a Type I error occurring somewhere within the analysis (Huck, 2000). Since the data analysis consisted of performing two separate factorial ANOVAs on each dependent variable based on the student characteristics and the performance variables, then the Bonferroni correction rate of .05/2 (.025) was utilized per the Bonferroni technique (Huck, 2000).

Mean differences. As mentioned previously, the researcher chose to perform a MANOVA on all of the independent and dependent variables to determine whether there were statistically significant differences in the sources of mathematical self-efficacy when their intercorrelations were taken into account. Based on the MANOVA, none of the independent variables nor their interactions were found to be statistically significant. Additionally, the changes between R^2 and the adjusted R^2 for each of the sources of self-efficacy indicated a huge loss in power (e.g. vicarious experience: $R^2 = .915$, adjusted $R^2 = -.236$). Since the four theorized sources of mathematical self-efficacy address distinct sources of information (Lent, Lopez, Brown, & Gore, 1996), which can be analyzed separately, and due to the loss in power of the MANOVA, the researcher felt justified in performing factorial ANOVAs on each of the sources of self-efficacy.

Factorial ANOVAs were important in this research study because they provided information regarding interaction effects of independent variables on the dependent variables. However, with a sample size of only 102 students and six independent variables with two or more levels each, factorial ANOVAs posed a problem. In order to analyze data, the number of students within each subcategory of the specific factorial ANOVA needed to be somewhat similar. When one subcategory did not contain any students (i.e. no males of "other races") or only a few compared to other subcategories, issues with analysis arose. In order to proceed with the factorial ANOVAs for each dependent variable, *Race* was re-classified with only two levels: African-American – 1 and Caucasian – 2.

In addition to the assumption of normally distributed scores on the dependent variables, ANOVAs require equal variances across the populations. The Levene's test of homogeneity assesses the null hypothesis that the variances are equal, which means that the researcher hopes to find a non-significant test statistic result (Warner, 2008). The Levene's test was non-significant for all but one factorial ANOVA (vicarious experience – self with student characteristics as the independent variable). The researcher chose to run three separate one-way ANOVAs for each of the student characteristic variables (gender, race and hometown location) on the vicarious experience – self dependent variable. The three one-way ANOVAs all passed the Levene's test of homogeneity. Furthermore, for each of the factorial and one-way ANOVAs, the researcher chose to include a Tukey honestly significant difference (HSD) post-hoc test, which "shows all possible pairwise comparisons of group means and reports whether each of these comparisons is significant" (Warner, 2008, p. 241). In other words, the Tukey HSD test will identify which of the levels of the variable, if any, have statistically significant mean differences.

Mastery experience. Each of the two factorial ANOVAs analyzed on the dependent variable, mastery experience, had one statistically significant result at the adjusted p = .025 level, but no interaction effects. Hometown location (see Table 4.2) and the letter grade received in the mathematics course from the previous semester (see Table 4.3) were found to be statistically significant independent variables.

Table 4.2

2x2x3 Factorial ANOVA on Mastery Experience with student characteristics as independent variables

Source	Type III SS	df	MS	F	p	Partial η^2	η^2
Corrected Model	23.69	11	2.15	1.72	.085	.20	.20
Gender	.02	1	.02	.02	.894	.00	.00
Home	13.02	2	6.51	5.19	.008*	.12	.11
Race	.32	1	.32	.26	.615	.00	.00
Gender * Home	4.02	2	2.01	1.60	.208	.04	.03
Gender * Race	1.33	1	1.33	1.06	.306	.01	.01
Home * Race	.84	2	.42	.34	.715	.01	.01
Gender * Home * Race	4.76	2	2.38	1.90	.157	.05	.04
Error	94.00	75	1.25				
Total	1620.63	87					
Corrected Total	117.70	86					

*p<.025

A student's hometown location was determined to statistically significantly influence the mastery experience score: $F(2, 75) = 5.19$, $p < .025$. This corresponds with an almost large effect size of $\eta^2 = .11$, which means that 11% of the variance in the mastery experience scores was predictable from the type of student's hometown location. The partial eta-squared value indicates that a student's hometown location accounts for 12% of the variance in the mastery experience score when all of the other variables are held constant. The Tukey HSD post-hoc test showed that the suburban students (M = 4.538, SD = 1.041) had a statistically significantly higher mastery experience score than the urban students (M = 3.716, SD = 1.305). Since hometown environment has not been analyzed with the sources of mathematical self-efficacy in the past, this result establishes a need for further research within this area.

Table 4.3

3x4x4 Factorial ANOVA on Mastery Experience with performance variables as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	60.07	28	21.45	2.67	.002	.66	.66
HSGPA2	2.22	2	1.11	1.38	.265	.07	.02
COLGPA2	2.27	3	.76	.94	.431	.07	.02
classgrd	20.29	3	6.76	8.40	<.001*	.39	.22
HSGPA2 * COLGPA2	2.87	6	.48	.60	.732	.08	.03
HSGPA2 * classgrd	7.11	6	1.19	1.47	.213	.19	.08
COLGPA2 * classgrd	2.48	6	.41	.51	.795	.07	.03
HSGPA2 * COLGPA2 * classgrd	.55	2	.28	.34	.713	.02	.01
Error	31.39	39	.81				
Total	1247.98	68					
Corrected Total	91.46	67					

Note. HSGPA2 – high school GPA; COLGPA2 – college GPA; classgrd – letter grade in mathematics course

*p < .025

The letter grade students received in their mathematics course from the previous semester was determined to be statistically significantly influential on the mastery experience construct: $F (3, 39) = 8.40$, $p < .025$. This corresponds to a large effect size of $\eta^2 = .22$, which means that about 22% of the variance in the mastery experience scores was predictable from the letter grade the students received in their mathematics course from the previous semester. The partial-eta squared value indicates that the letter grade from the mathematics course the previous semester accounts for 39% of the variance in the mastery experience scores when all of the other variables are held constant. The Tukey HSD post-hoc test showed that students who self-reported an A in their mathematics course in the previous semester (M = 5.08, SD = 0.56) had a statistically significantly higher mastery experience score than those students who had a C (M = 3.52, SD = 1.17) or those who had a D or below (M = 3.15, SD = 1.11). Additionally, the Tukey HSD post-hoc test showed that students who self-reported a B in their mathematics course from the previous semester (M =4.30, SD = 0.84) had a statistically significantly higher mastery experience score than those who had a D or below (M = 3.15, SD = 1.11).

Warner (2008) explains how a significant *F*-test could yield non-significant Tukey HSD results for all level comparisons, because the Tukey HSD test “requires a slightly larger difference between means to achieve significance” (p. 247). However, the researcher could not find a reasonable explanation as to why a non-significant *F*-test, such as the one for the students’ college GPA, did have statistically significant differences in the levels of the variable on the Tukey HSD test at the adjusted p-value. According to the Tukey HSD test, students who reported a college GPA of 3.5 or above

(M = 4.997, SD = .736) had a statistically significantly higher mastery experience score than students who had a GPA of 2.50 – 2.99 (M = 3.581, SD = 1.158) or those who had a GPA below 2.5 (M = 3.454, SD = 1.003). The researcher chose to include this information within the analysis discussion, but encourages others to interpret the information with caution.

Vicarious experience. Each of the two factorial ANOVAs analyzed on the dependent variable, vicarious experience, had no statistically significant results at the adjusted p-value of .025. However, the *p*-value (.046) for the students' hometown environment (see Table 4.4), and the *p*-value (.044) for the letter grade received in the mathematics course taken the previous semester (see Table 4.5) warrant further research.

Table 4.4

2x2x3 Factorial ANOVA on the dependent variable, vicarious experience, with student characteristics as independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	17.63	11	1.60	1.97	.044	.22	.22
Gender	.54	1	.54	.66	.419	.01	.01
Home	5.22	2	2.61	3.20	.046	.08	.07
Race	.41	1	.41	.51	.479	.01	.01
Gender * Home	2.46	2	1.23	1.51	.228	.04	.03
Gender * Race	.32	1	.32	.40	.530	.01	.00
Home * Race	1.13	2	.56	.69	.505	.02	.01
Gender * Home * Race	2.61	2	1.30	1.60	.209	.04	.03
Error	61.16	75	.82				
Total	1334.31	87					
Corrected Total	78.79	86					

Additionally, even though the F-test was not significant, the Tukey HSD test found that students who self-reported an A (M = 4.28, SD = 0.84) in their mathematics course taken in the previous semester had statistically significantly higher vicarious experience scores than those students who had a D or below (M = 3.25, SD = 0.80). The researcher chose to include this statistical difference, but encourages others to interpret it with caution.

Table 4.5

3x4x4 Factorial ANOVA on the dependent variable, vicarious experience, with performance variables as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	24.15	28	.86	.87	.644	.39	.39
HSGPA2	1.09	2	.55	.55	.580	.03	.02
COLGPA2	1.82	3	.61	.61	.610	.05	.03
classgrd	8.80	3	2.93	2.97	.044	.19	.14
HSGPA2 * COLGPA2	2.01	6	.34	.34	.912	.05	.03
HSGPA2 * classgrd	3.51	6	.59	.59	.735	.08	.06
COLGPA2 * classgrd	.97	6	.16	.16	.985	.03	.02
HSGPA2 * COLGPA2 * classgrd	1.54	2	.77	.78	.465	.04	.02
Error	38.59	39	.99				
Total	1014.50	68					
Corrected Total	62.74	67					

Note. HSGPA2 – high school GPA; COLGPA2 – college GPA; classgrd – letter grade of mathematics course

Verbal and social persuasions. The factorial ANOVA on the dependent variable, verbal and social persuasions, with the student characteristics as the independent variables did not have any statistically significant results at the adjusted $p = .025$ level (see Table 4.6). However, the *p*-value (.030) of the student's hometown environment warrants further research. Additionally, the factorial ANOVA on the dependent variable, verbal and social persuasions, was statistically significantly influenced at the adjusted $p = .025$ level based on the letter grade received in the mathematics course from the previous semester (see Table 4.7).

The letter grade students received in their mathematics course from the previous semester was determined to be statistically significantly influential on the verbal and social persuasions construct: F (3, 39) = 4.37, p < .025. This corresponds to a large effect size of η^2 = .15, which means that about 15% of the variance in the verbal and social persuasions scores was predictable from the letter grade the students received in their mathematics course from the previous semester. The partial-eta squared value indicates that the letter grade from the mathematics course the previous semester accounts for 25% of the variance in the verbal and social persuasions scores when all of the other variables are held constant. The Tukey HSD post-hoc test showed that students who self-reported an A (M = 4.48, SD = .93) in their mathematics course in the previous semester had a statistically significantly higher verbal and social persuasions score than those students who had a C (M = 2.53, SD = 1.31) or those who had a D or below (M = 3.06, SD = 1.27). Since students who receive an A in their courses are more likely to earn verbal praises from family and friends, it seems appropriate for their verbal and social persuasions scores to be higher than those students who received a C or below.

Table 4.6

2x2x3 Factorial ANOVAs on the dependent variable, verbal and social persuasions, with the student characteristics as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	33.74	11	3.07	1.72	.085	.20	.20
Gender	.50	1	.50	.28	.598	.00	.00
Home	13.08	2	6.54	3.67	.030	.09	.08
Race	.68	1	.68	.38	.538	.01	.00
Gender * Home	7.31	2	3.66	2.05	.135	.05	.04
Gender * Race	.98	1	.98	.55	.461	.01	.01
Home * Race	.91	2	.46	.26	.775	.01	.01
Gender * Home * Race	6.31	2	3.16	1.77	.177	.05	.04
Error	133.58	75					
Total	1242.19	87					
Corrected Total	167.32	86					

Table 4.7

3x4x4 Factorial ANOVA on the dependent variable, verbal and social persuasions, with the performance variables as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	76.78	28	2.74	1.84	.039	.57	.57
HSGPA2	8.23	2	4.12	2.76	.076	.12	.06
COLGPA2	1.65	3	.55	.37	.777	.03	.01
Classgrd	19.57	3	6.52	4.37	.010*	.25	.15
HSGPA2 * COLGPA2	4.62	6	.77	.52	.793	.07	.03
HSGPA2 * classgrd	8.67	6	1.45	.97	.459	.13	.06
COLGPA2 * classgrd	5.09	6	.85	.57	.753	.08	.04
HSGPA2 * COLGPA2 * classgrd	2.68	2	1.34	.90	.416	.04	.02
Error	58.16	39	1.49				
Total	968.17	68					
Corrected Total	134.93	67					

Note. HSGPA2 – high school GPA; COLGPA2 – college GPA; classgrd – letter grade of mathematics course

*$p < .025$

Physiological and emotional states. The factorial ANOVA on the dependent variable, physiological and emotional states, with the student characteristics as the independent variables did not have any statistically significant results at the adjusted $p = .025$ level (see Table 4.8). The factorial ANOVA on the dependent variable, physiological and emotional states, was statistically significantly influenced at the adjusted $p = .025$ level based on the letter grade received in the mathematics course from the previous semester (see Table 4.9).

Table 4.8

2x2x3 Factorial ANOVA on the dependent variable, physiological and emotional states, with the student characteristics as the independent variable

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	15.69	11	1.43	.93	.515	.12	.12
Gender	.04	1	.04	.03	.871	.00	.00
Home	8.46	2	4.23	2.76	.069	.07	.06
Race	3.40	1	3.40	2.22	.140	.03	.03
Gender * Home	3.26	2	1.63	1.07	.349	.03	.02
Gender * Race	.53	1	.53	.35	.557	.01	.00
Home * Race	.68	2	.34	.22	.802	.01	.01
Gender * Home * Race	.37	2	.19	.12	.886	.00	.00
Error	114.73	75	1.53				
Total	1504.87	87					
Corrected Total	130.42	86					

The letter grade students received in their mathematics course from the previous semester was determined to be statistically significantly influential on the physiological and emotional states construct: F (3, 39) = 5.95, p < .025. This corresponds to a large effect size of $\eta^2 = .20$, which means that about 20% of the variance in the physiological and emotional states scores was predictable from the letter grade the students received in their mathematics course from the previous semester. The partial-eta squared value indicates that the letter grade from the mathematics course the previous semester accounts for 31% of the variance in the physiological and emotional states scores when all of the other variables are held constant. The Tukey HSD post-hoc test showed that students who self-reported an A (M = 4.81, SD = 0.96) in their mathematics course in the previous semester had a statistically significantly higher physiological and emotional states score than those students who had a C (M = 3.14, SD = 1.21) or those who had a D or below (M = 3.40, SD = 1.17). The Tukey HSD test also showed that students who self-reported a B (M = 4.19, SD = 1.27) in their mathematics course in the previous semester had a statistically significantly higher physiological and emotional states score than those who had a C (M = 3.14, SD = 1.21). Additionally, even though the F-test was not statistically significant for college GPA, the Tukey HSD test found that students who had a college GPA of 3.50 or above (M = 4.61, SD = 1.15) had statistically significantly higher physiological and emotional states scores than those students who had a college GPA of 2.50 – 2.99 (M = 3.68, SD = 1.50). The researcher chose to include this statistical difference, but encourages others to interpret it with caution.

Table 4.9

3x4x4 Factorial ANOVA on the dependent variable, physiological and emotional states, with the performance variables as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	65.57	28	2.34	1.86	.037	.57	.57
HSGPA2	1.74	2	.87	.69	.507	.03	.02
COLGPA2	6.09	3	2.03	1.61	.203	.11	.05
classgrd	22.55	3	7.52	5.95	.002*	.31	.20
HSGPA2 * COLGPA2	6.57	6	1.10	.87	.528	.12	.06
HSGPA2 * classgrd	10.52	6	1.75	1.39	.244	.18	.09
COLGPA2 * classgrd	6.79	6	1.13	.90	.507	.12	.06
HSGPA2 * COLGPA2 * classgrd	.56	2	.28	.22	.801	.01	.00
Error	49.25	39	1.26				
Total	1194.04	68					
Corrected Total	114.82	67					

Note. HSGPA2 – high school GPA; COLGPA2 – college GPA; classgrd – letter grade of mathematics course

*p < .025

Vicarious experience – adult role model. Each of the two factorial ANOVAs analyzed on the dependent variable, vicarious experience – adult role models, with student characteristics (see Table 4.10) and performance variables (see Table 4.11) as the independent variables had no statistically significant results at the adjusted p-value of .025. However, the *p*-value (.028) for the letter grade received in the mathematics course taken the previous semester with a large effect size of η^2 = .15 warrants further research.

Table 4.10

2x2x3 Factorial ANOVA on the dependent variable, vicarious experience – adult role models, with the student characteristics as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	11.40	11	1.04	.82	.619	.11	.11
Gender	.03	1	.03	.02	.877	.00	.00
Home	4.32	2	2.16	1.71	.188	.04	.04
Race	.01	1	.01	.01	.921	.00	.00
Gender * Home	1.94	2	.97	.77	.467	.02	.02
Gender * Race	.01	1	.01	.01	.917	.00	.00
Home * Race	1.15	2	.58	.46	.636	.01	.01
Gender * Home * Race	2.24	2	1.12	.89	.416	.02	.02
Error	94.62	75	1.26				
Total	1462.25	87					
Corrected Total	106.02	86					

Table 4.11

3x4x4 Factorial ANOVA with the dependent variable, vicarious experience – adult role models, with the performance variables as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	36.74	28	1.31	1.09	.394	.44	.44
HSGPA2	.85	2	.42	.35	.706	.02	.01
COLGPA2	2.66	3	.89	.74	.536	.05	.03
classgrd	12.17	3	4.06	3.37	.028	.21	.15
HSGPA2 * COLGPA2	7.19	6	1.20	1.00	.441	.13	.09
HSGPA2 * classgrd	14.42	6	2.40	2.00	.089	.24	.17
COLGPA2 * classgrd	3.24	6	.54	.45	.842	.07	.04
HSGPA2 * COLGPA2 * classgrd	.71	2	.36	.30	.746	.02	.01
Error	46.89	39	1.20				
Total	1120.25	68					
Corrected Total	83.63	67					

Note. HSGPA2 – high school GPA; COLGPA2 – college GPA; classgrd – letter grade of mathematics course

Vicarious experience – peer. Each of the two factorial ANOVAs analyzed on the dependent variable, vicarious experience – peer role models, with student characteristics (see Table 4.12) and performance variables (see Table 4.13) as the independent variables had no statistically significant results at the adjusted p-value of .025. However, the *p*-value (.035) for the interaction effects of gender and hometown environment with a medium effect size of $\eta^2 = .07$ warrants further research.

Table 4.12

2x2x3 Factorial ANOVA with dependent variable, vicarious experience – peer role model, with student characteristics as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	25.53	11	2.32	1.93	.049	.22	.22
Gender	.01	1	.01	.01	.933	.00	.00
Home	6.58	2	3.29	2.73	.072	.07	.05
Race	.05	1	.05	.04	.838	.00	.00
Gender * Home	8.45	2	4.23	3.51	.035	.09	.07
Gender * Race	.01	1	.01	.01	.915	.00	.00
Home * Race	1.46	2	.73	.61	.547	.02	.01
Gender * Home * Race	5.01	2	2.51	2.08	.132	.05	.04
Error	90.32	75	1.20				
Total	136.00	87					
Corrected Total	115.85	86					

Table 4.13

3x4x4 Factorial ANOVA with the dependent variable, vicarious experience – peer role model, with performance variables as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	38.15	38	1.36	.92	.587	.40	.40
HSGPA2	.89	2	.44	.30	.743	.02	.01
COLGPA2	1.00	3	.33	.23	.878	.02	.01
classgrd	8.07	3	2.69	1.82	.160	.12	.08
HSGPA2 * COLGPA2	9.46	6	1.58	1.06	.400	.14	.10
HSGPA2 * classgrd	6.60	6	1.10	.74	.619	.10	.07

Table 4.13 (continued)

COLGPA2 * classgrd	3.32	6	.55	.37	.892	.05	.03
HSGPA2 * COLGPA2 * classgrd	3.45	2	1.73	1.17	.323	.06	.04
Error	57.80	39	1.48				
Total	1018.75	68					
Corrected Total	95.95	67					

Note. HSGPA2 – high school GPA; COLGPA2 – college GPA; classgrd – letter grade of mathematics course

Vicarious experience – self role model. As was mentioned earlier in this chapter, the subcategory of the vicarious experience construct pertaining to the self generated role model failed the homogeneity assumption for the factorial ANOVA using the student characteristics as the independent variables. The researcher chose to run three one-way ANOVAs on the vicarious experience – self dependent variable for each of the student characteristics, gender, race, and hometown location, (see Tables 4.14, 4.15, and 4.16, respectively) Since each of the factorial ANOVAs on the student characteristics was using the adjusted p-value of .025 and the homogeneity assumption failed for this subcategory of the vicarious experience construct, the researcher divided the error rate of .025 by three for each of the one-way ANOVAs to keep the overall Type I error rate at 0.5. Thus the .025 p-value was further adjusted to a p-value of .025/3, or approximately .008, based on the Bonferroni correction technique.

Gender was the only independent variable (including the performance variables in the factorial ANOVA – see Table 4.17) found to statistically significantly influence the vicarious experience - self score: $F(1, 100) = 9.03$, $p < .008$. This corresponds with a medium effect size of $\eta^2 = .08$, which means that 8% of the variance in the vicarious experience - self scores was predictable from the gender of the students. Male students ($M = 4.06$, $SD = 1.20$) had a higher vicarious experience - self score than female students

(M = 3.31, SD = 1.31). Additionally, the *p*-value (.016) for race with a medium effect size of $\eta^2 = .07$ warrants further research on how race influences the subcategory of the vicarious experience construct pertaining to the self generated role model.

Table 4.14

One-Way ANOVA on the dependent variable, vicarious experience self role model, with the independent variable, gender

Source	SS	df	MS	F	*p*
Between Groups	14.25	1	14.25	9.03	.003*
Within Groups	157.77	100	1.58		
Total	172.02	101			

* $p < .008$, $\eta^2 = .08$

Table 4.15

One-Way ANOVA on the dependent variable, vicarious experience self role model, with the independent variable, race

Source	SS	df	MS	F	*p*
Between Groups	9.68	1	9.68	6.03	.016
Within Groups	136.57	85	1.61		
Total	146.25	86			

$\eta^2 = .07$

Table 4.16

One-Way ANOVA on the dependent variable, vicarious experience self role model, with the independent variable, hometown environment

Source	SS	df	MS	F	*p*
Between Groups	5.66	2	2.83	1.68	.191
Within Groups	166.36	99	1.68		
Total	172.02	101			

$\eta^2 = .03$

Table 4.17

3x4x4 Factorial ANOVA with the dependent variable, vicarious experience with self role model, with the performance variables as the independent variables

Source	Type III SS	df	MS	F	*p*	Partial η^2	η^2
Corrected Model	47.37	28	1.69	.99	.502	.42	.42
HSGPA2	10.94	2	5.47	3.21	.051	.14	.10
COLGPA2	2.24	3	.75	.44	.727	.03	.02
classgrd	12.58	3	4.19	2.46	.077	.16	.11
HSGPA2 * COLGPA2	5.77	6	.96	.56	.756	.08	.05
HSGPA2 * classgrd	7.16	6	1.19	.70	.652	.10	.06
COLGPA2 * classgrd	4.27	6	.71	.42	.863	.06	.04
HSGPA2 * COLGPA2 * classgrd	2.77	2	1.38	.81	.452	.04	.02
Error	66.55	39	1.71				
Total	1014.75	68					
Corrected Total	113.92	67					

Note. HSGPA2 – high school GPA; COLGPA2 – college GPA; classgrd – letter grade of mathematics course

Conclusion

This research study determined several substantial results for the student characteristics and the performance variables on the four sources of mathematical self-efficacy and the subcategories of the vicarious experience construct at the adjusted p-value of .025 based on the Bonferroni correction technique with medium to large effect sizes.

- Gender was determined to have a statistically significant impact on vicarious experience – self with males scoring higher than females.
- Hometown environment was determined to have a statistically significant impact on mastery experience with suburban students scoring higher than urban students.

- The grade received in the math course the previous semester was found to have a statistically significant impact on three of the four sources of mathematical self-efficacy at the adjusted p-value of .025.
- Based on all three performance variables (high school GPA, college GPA, and letter grade of the mathematics course taken the previous semester), only the letter grade had a statistically significant influence on several of the dependent variables.
- Race and high school GPA did not have a statistically significant influence on any of the dependent variables at the adjusted p-value of .025, but some of their p-values warrant further research.
- College GPA did not have a statistically significant influence on any of the dependent variables.
- Even though this research study did not determine any statistically significant interaction effects between any of the independent variables on any of the dependent variables, the p-value (.035) of the interaction of gender and hometown environment on the peer role model subcategory of the vicarious experience construct warrants further research.

Chapter V: Discussion, Conclusions and Implications

The final chapter of this study focuses on analytical interpretations regarding the research question (What student characteristics influence the four sources of mathematical self-efficacy?) and the future directions for research.

Factors Influencing Sources of Mathematical Self-Efficacy

Since the data analysis yielded no interaction effects between the selected independent variables on any of the dependent variables at the adjusted rate of .025, the factors influencing the sources of mathematical self-efficacy will be discussed based on each of the independent variables and the future directions for research in each area.

Gender. Gender was found to have a statistically significant impact on vicarious experience – self at the further adjusted rate of .008. Vicarious experience is the cognitive processing of competence generated by the comparisons of oneself with others. When researchers discuss vicarious experience many of the comparisons are made based on the adult or peer role models. However, people can also compare themselves to their own past performances, which will lead to a self-generated role model (Usher & Pajares, 2009). Within this research study, male students were statistically more likely to utilize this self-comparison role model than the female students.

In his article *Sexual Selection and Sex Differences in Mathematical Abilities*, Geary (1996) analyzes cross-national patterns of sex differences in mathematical abilities utilizing the principles of sexual selection as the framework. Within his comparison of the classroom experiences of male and female students he discusses a particular study conducted by Peterson and Fennema, *Effective Teaching, Student Engagement in Classroom Activities, and Sex-related Differences in Learning Mathematics* (1985), on 36 fourth-grade classrooms, which suggested that competitive and cooperative classroom environments benefited one gender but was a detriment to the other. Boys had markedly higher mathematical achievement within a competitive environment, but were hindered within a cooperative environment. Girls were found to be affected in the complete opposite manner.

Based on this idea of competition found within the male domain, the vicarious experience – self construct has more merit. If a male student does not have a strong adult or peer role model, then the competitive nature within him creates a self-generated model with whom to compare and compete. On the other hand, male students may just be more likely to compete with this self-comparison even if a strong adult or peer role model is available. This idea of a self-generated role model has not been found within other research studies; except this study and the Usher & Pajares' (2009) study. More research should be conducted on the subcategories (adult, peer and self) of the vicarious experience construct to determine whether gender continues to impact one or more of those subcategories. It may also be informative to include an additional subcategory pertaining to prominent role models from society.

Race. Even though this student characteristic was not found to be statistically significant within the scope of this research study at the further adjusted rate of .008, a p-value of .016 on the vicarious experience – self construct warrants more research. Interestingly, based on the mean average scores on the three subcategories of vicarious experience, African-American students in this study favored vicarious experience – self over the other two subcategories while it ranked last with the Caucasian students. This corresponds with the idea that the construct of self is a prevalent theme found in the psychological research of African Americans (Graham, 1994). In her review of nearly 140 studies, Graham concluded that a "motivational psychology for African Americans must explicitly be concerned with the self" (p. 104). However, she explains that researchers cannot determine the questions about African American self-perceptions by looking at a comparison of self-perceptions between African-American and White students. She suggests using the construct of self as a framework for pursuing research on the interaction of self and achievement within a homogenous African-American study. This research study supports her contention.

In addition, based on the mean average scores for the four sources of mathematical self-efficacy, African-American students within this study favored physiological & emotional states over mastery experience while the Caucasian students had them reversed. The idea of relating to the physiological & emotional states before mastery experience may correspond to the struggles African-American students experience in mathematics. In a case study of two African-American college females (Moody, 2004), Ashley and Sheilah, Ashley characterized her mathematical experience by focusing on the struggles and obstacles she faced. However, Sheilah's perception was to overcome any obstacles by working hard and achieving the goal. Sheilah had African-American role models like her mother, who had obtained a master's degree in mathematics, as well as other African-American mathematics teachers and mathematically high achieving African-American peers to validate her own ability to achieve. The African-American role models within the mathematical world of the students may help African-American students change their focus from the stresses and struggles of mathematics to the feelings of encouragement and hope (Moody, 2004).

Future research should focus on how African-American mathematical role models impact the sources of mathematical self-efficacy.

Hometown environment. A student's hometown environment (rural, urban or suburban) could have an impact on the four sources of self-efficacy based on the types of role models present within the community, percentage of parental involvement, and types of verbal and social persuasion from the family unit and community. This student characteristic was found to be statistically significant within the scope of this research study at the adjusted rate of .025 on the mastery experience construct. Since this type of independent variable has not been included in studies pertaining to the sources of mathematical self-efficacy, the statistically significant results demonstrate a need for further research. In addition, based on the mean average scores for the four sources of mathematical self-efficacy, rural and suburban students within this study favored mastery experience, first; physiological & emotional states, second; vicarious experience, third; and verbal & social persuasions, last. Whereas, urban students within this study favored physiological & emotional states, first; mastery experience, second; closely followed by vicarious experience, third; and then verbal & social persuasions.

Since students would have spent more time acclimating to their own hometown environment, it makes sense that it would impact various areas of their lives, including their self-efficacy. However, as a student integrates more into the college environment and is surrounded by people from various backgrounds, the impact of the hometown environment on the sources of self-efficacy may begin to lessen. A longitudinal study focusing on the impact of the hometown environment on the four sources of mathematical self-efficacy would be informative.

High school GPA. Even though this performance variable was not found to be statistically significant within the scope of this research study at the adjusted rate of .025, a p-value of .076 with a medium effect size ($\eta^2 = .06$) on the mastery experience construct and a p-value of .051 with a medium effect size of ($\eta^2 = .10$) on the self generated role model subcategory of the vicarious experience construct warrants more investigation. Since a student's high school GPA is a performance outcome based on all courses taken within the high school years, it would seem likely to correspond with the mastery experience construct. On the other hand, the overall high school performance outcome does not correspond with how efficacious a student feels regarding his/her mathematical abilities. Thus, the Sources of Middle School Mathematics Self-Efficacy Scale (Usher & Pajares, 2009) revised for this research study provides a more accurate assessment of the informative nature of the sources of self-efficacy than the scale developed by Matsui, Matsui, and Ohnishi (1990), because their mastery experience construct was determined by the self-reported high school mathematics grade. Using high school GPA as a means of measuring mastery experience of mathematics or academics in general goes against the tenets of Bandura's (1997) social cognitive theory.

College GPA. This performance variable was not found to be statistically significant within the scope of this research study at the adjusted rate of .025 for any of the dependent variables, which supports Bandura's (1997) tenet, that a numerical value, such as GPA, does not measure the overall efficaciousness of a student. Even though this student characteristic was not found to be statistically significant on any of the sources of mathematical self-efficacy, the Tukey HSD test did find statistically significant mean differences in the scores of the physiological and emotional states construct. Students who had a college GPA of 2.50 – 2.99 had a lower score than students with a GPA of 3.5 or higher. It is reasonable that a student with a higher college GPA would not feel anxious or depressed about mathematics. However, some of the students in the study had not taken a college-level mathematics course, which could be the reason for the mixed results. Regardless of the results of the Tukey HSD test, the tenets of Bandura's (1997) social cognitive theory does not support using a performance variable as a measure of any of the sources of mathematical self-efficacy.

Mathematics course grade. The grade received in the mathematics course taken the previous semester was the only performance variable found to statistically significantly influence the sources of mathematical self-efficacy. It was found to have a statistically significant impact on three of the four sources of mathematical self-efficacy (*mastery experience*, *verbal and social persuasions*, and *physiological and emotional states*) at the adjusted rate of .025. This performance outcome is more closely associated with the sources of mathematical self-efficacy, based on its statistical significance with three of the four sources, than even college GPA, because these students had already experienced a college-level mathematics course. Even though this variable highly corresponds with the sources, researchers are cautioned not to use the grade as a means of assessing mastery experience or any of the other sources, because it does not account for how a student cognitively interprets the grade received and it goes against the tenets of the social cognitive theory. Furthermore, a p-value of .028 on the vicarious experience – adult construct, a p-value of .077 on the vicarious experience – self construct warrants more research within this area as well.

Sexual orientation. Due to the small sample size and the large percentage (88.2%) of heterosexual students, it was not possible to analyze this particular student characteristic within the scope of this research study. The small number of homosexual and bisexual students in this sample may have been associated with the religious affiliation of the institutions participating in the research study. However, the lack or nonexistence of research in this area regarding the sources of mathematical self-efficacy indicates that more research should be conducted with attention to the sexual orientation of students, especially since some research (Rahman & Wilson, 2003; Peters, Manning, & Reimers, 2007) has found statistically significant differences between gender and sexual orientation on tests of spatial processing, such as the mental rotation task (MRT). Future research should be conducted on public institutions without religious affiliation to generate a more diverse sample.

Discussion

The purpose of this descriptive, survey research study was to determine which student characteristics (race, gender, sexual orientation and hometown location) influence the sources of mathematical self-efficacy of college freshmen, if any, utilizing a valid assessment tool aligned with the tenets of the self-efficacy theory. Based on the concept that “personal agency is socially rooted and operates within sociocultural influences, individuals are viewed both as products and producers of their own environments and of their social systems” (Pajares, 1996, p. 544), the researcher hypothesized that groups of students would be influenced by similar sources of self-efficacy (i.e. the *vicarious experience* score of the participants will be influenced by their race or the *verbal and social persuasion* score will be influenced by a student’s hometown location). This study, utilizing the valid assessment tool designed by Usher and Pajares (2009) slightly modified for college students, confirmed the hypothesis for two independent variables.

Mastery experience was found to be influenced by the hometown environment with suburban students scoring higher than urban students. Since the hometown environment of students has not been analyzed in previous research studies, this statistically significant result indicates a need for further research on this particular student characteristic. Additionally, *mastery experience*, *verbal and social persuasions*, and *physiological and emotional states* was found to be influenced by the grade received in the mathematics course taken the previous semester. The statistically significant influence of this performance variable on several of the sources of mathematical self-efficacy is not surprising based on the fact that grades are often used as the sole measure of ability within the educational system. However, using a student's previous grade in a particular course to analyze the sources of self-efficacy does not correspond with the tenets of Bandura's (1997) social cognitive theory.

In their qualitative study of successful women in STEM career fields, Zeldin and Pajares (2000) determined that vicarious experience and verbal and social persuasions were highly influential with their participants. However, gender did not have a statistically significant impact on any of the four sources of mathematical self-efficacy within this research study. This difference could be a result of the small sample size (n=102) of this research study, small sample size of their qualitative research study (n=15), or the results of their single-gendered study. Since their research study did not include an analysis of successful males in STEM career fields, it is not possible to state definitively that women are more influenced by vicarious experiences or verbal and social persuasions. It is possible that males would have answered those same questions in a similar manner. Additionally, students interested in pursuing STEM careers would be expected to have higher mathematical self-efficacy than those who are not pursuing those careers. Since this current research study did not ascertain the interests of the students to pursue STEM related careers, it is not possible to determine whether this interest significantly impacted possible gender differences.

Gender was found in the current research study to have a statistically significant influence on the self-generated role model subcategory of the vicarious experience construct. Males scored higher than females on this particular dependent variable. Race and the interaction of gender with hometown environment produced p-values of interest for at least one of the subcategories as well. However, the low reliability of the three subcategory items (adult: $\alpha = 0.52$, peer: $\alpha = 0.51$, and self: $\alpha = 0.62$) limits the interpretability of the findings.

Stevens et al. (2004) determined that prior mathematics achievement was more influential for Hispanic students than for Caucasian students, which may cause others to believe that race would have a statistically significant influence on the sources of mathematical self-efficacy, or at least the mastery experience construct. However, within the scope of this small research study, race was not found to be statistically significant for any of the four sources. One reason for this particular difference is the manner in which Stevens et al. assessed the prior mathematics achievement. They had students self-report the grade they normally made in mathematics courses instead of analyzing the mastery experience construct within the frame of the tenets of the social cognitive theory. Race may have an influence on the sources of mathematical self-efficacy, but the small sample size of the current study could have contributed to the non-significant results.

Even though Usher and Pajares confirmed the validity and reliability of their Sources of Middle School Mathematics Self-Efficacy Scale within their study (2009), investigating the impact of student characteristics, such as gender and ethnicity, on the sources of mathematical self-efficacy was beyond the scope of their study. Thus, the results within this research study provides the first analysis of the impact of student characteristics on the four sources of mathematical self-efficacy utilizing their scale, but slightly adapted for college level students.

The fact that each person is a combination of environmental, personal and behavioral factors may explain the limited statistically significant results obtained from this research study and may also explain some of the obstacles mathematics teachers face while trying to guide students to mathematical success. Mathematics teachers have an obligation to help enhance the mathematical self-efficacy of all students, especially during this highly technologically advanced period of history. Focusing on ways to enhance each of the four sources of self-efficacy during the course of the mathematics class is one way to enhance the overall mathematical self-efficacy of all students.All students have a capacity to learn mathematics, but the capacity is influenced by familial, biological, environmental, and social factors. Teachers must focus on providing the best social and environmental arenas conducive to learning by making their classrooms a safe haven for curiosity, exploration and mistakes. No one builds knowledge without some struggles and errors. Students may be scared about making mistakes or may be embarrassed to be wrong in front of their peers, but mistakes should be celebrated for their learning potential. Teachers must establish an environment of mutual respect for all students by modeling respect for all individuals and providing encouragement throughout the learning process. Within a respectful, student-centered environment, students will feel free to search for answers through multiple strategies and discover that learning is a life-long process. By creating a safe haven for curiosity, exploration, celebration of mistakes, and respect for all individuals, teachers will ultimately help enhance all four of the sources of self-efficacy.

Conclusion

In Usher & Pajares' *Sources of Self-Efficacy in School: Critical Review of the Literature and Future Directions* (2008), the only student characteristics within the critical review pertained to gender, ethnicity and academic level. This research study was able to add to the literature by discussing the statistically significant results of a new student characteristic: hometown environment. Additionally, this study introduced the idea of another new student characteristic, sexual orientation, to the study of the sources of mathematical self-efficacy, but due to the nature of the participants no analysis was able to be performed. These two new student characteristics should be investigated further within a more diverse population from larger, public institutions, because they may provide further insight into the connection between students and their sources of mathematical self-efficacy.

In addition, this study provided further insight into the connection of gender, race, and the performance outcomes (high school GPA, college GPA, and the grade received in a math course the semester prior to the research study) with the sources of mathematical self-efficacy. Furthermore, this research study made slight modifications to the Sources of Middle School Mathematics Self-Efficacy Scale (2008) for use with college-level students and, through the Bayesian estimation approach, confirmed the factor loadings of the 24-item scale. Future research in secondary and post-secondary education should continue to analyze the validity and structure of this scale while assessing the impact of student characteristics on the sources of mathematical self-efficacy.

APPENDIX A

Custom Listings Categories and Selections for the Research Study

Undergraduate Instructional Program – selected all arts and science plus professional baccalaureates with some graduate coexistence

1) A&S + Prof/SGC
2) Bal/SGC
3) Prof + A&S/SGC

Graduate Instructional Program – selected only single post baccalaureate institutions

1) S-Post bac/Ed
2) S-Post bac/Bus
3) S-Post bac/Other

Enrollment Profile – selected institutions with majority or more undergraduate populations

1) VHU: Very high undergraduate
2) HU: High undergraduate
3) MU: Majority undergraduate

Undergraduate Profile – selected all full time four year institutions

1) FT4/I: Full-time four year, inclusive
2) FT4/S/LTI: Full-time four year, selective, lower transfer-in
3) FT4/S/HTI: Full-time four year, selective, higher transfer-in
4) FT4/MS/LTI: Full-time four year, more selective, lower transfer-in
5) FT4/MS/HTI: Full-time four year, more selective, higher transfer-in

Size and Setting – selected all small and very small institutions

1) VS4/NR: Very small four year, primarily nonresidential
2) VS4/R: Very small four year, primarily residential
3) VS4/HR: Very small four year, highly residential
4) S4/NR: Small four-year, primarily nonresidential
5) S4/R: Small four-year, primarily residential
6) S4/HR: Small four-year, highly residential

Basic Classifications – selected all options pertaining to baccalaureates

1) Bac/A&S: Baccalaureate Colleges – Arts and Science
2) Bac/Diverse: Baccalaureate Colleges – Diverse Fields
3) Bac/Assoc: Baccalaureate Colleges – Associate's Colleges

Final filtering stage involved selecting 4-year or above and private, not-for-profit institutions. The final six institutions selected for participation in this research study:
Alderson Broaddus College, WV; Averett University, VA; Blue Mountain College, MS; Kansas Wesleyan University, KS; Saint Gregory's University, OK; Wilson College, PA

APPENDIX B

Letter to Students

Dear Student,

Your college is one of three institutions participating in a research study pertaining to the level of confidence in the mathematical abilities of first year college students. Your assistance with this study will help further this research and hopefully result in providing colleges and universities with the information to help them strengthen the mathematical confidence of future students. You are being invited to participate in this study by submitting your responses to a very quick online survey. Your survey responses will be returned electronically verifying your submission but with no identifying information. In the final research documentation, the name of your college will not be included either. If you agree to participate in this research study, your name will be placed in a drawing for two separate $50 online gift cards.

Every person is unique and all responses are important to paint a more accurate picture of the mathematical confidence level of college freshman. Even though your response to this survey instrument is needed to provide sufficient data for the analysis, your participation in this study is completely voluntary. You may withdraw from the study at any time, as well as refuse to answer any questions. Students under the age of 18 are not allowed to participate in this research study. For further information regarding the research study including the rights of the participants and the confidentiality of the data go to www.tonjalocklear@weebly.com.

The survey should only take about 10 minutes or less of your time. Please answer the questions as honestly as possible. Once you submit your responses to the questionnaire, you will be giving your informed consent to participate in this research study.

When you are ready to begin the survey, please click the following link. <URL>

Thanks again for participating!

Tonja M. Locklear
Doctoral Candidate
STEM Education Department
University of Kentucky

APPENDIX C

Research Survey

Directions: Please place an X next to the appropriate response.

Gender: Female ____ Male ____

Race: African American ____ Caucasian ____ Other ____

Sexual Orientation: Bisexual ____ Heterosexual _____ Homosexual ____

Hometown: Is your home in a more rural (country) area, urban (city) area, or suburban area?

Rural ____ Urban ____ Suburban ____

High School GPA: _____

College GPA: _____

Did you take a math course last semester? Yes ____ No ____

If Yes, what letter grade did you earn in the math course? ____

Directions: Below are some statements about ***math***. ***Tell us how true or false each statement is for you*** by **circling the letter** that best describes you.

F	F	F	T	T	T
***Definitely* False**	**Mostly False**	**A little bit False**	**A little bit True**	**Mostly True**	***Definitely* True**

1	I make excellent grades on math tests.	F F F T T T
2*	Seeing students do better than me in math helps me do better in math.	F F F T T T
3	Just being in math class makes me feel stressed and nervous.	F F F T T T

4	I have always been successful with math.	F	F	F	T	T	T
5	Doing math work takes all of my energy.	F	F	F	T	T	T
6	My math teachers have told me that I am good at learning math.	F	F	F	T	T	T
7	I start to feel stressed-out as soon as I begin my math work.	F	F	F	T	T	T
8	People have told me that I have a talent for math.	F	F	F	T	T	T
9	Even when I study very hard, I do poorly in math.	F	F	F	T	T	T
10*	I got good grades in my last math class.	F	F	F	T	T	T

11	Adults in my family have told me what a good math student I am.	F	F	F	T	T	T
12	My mind goes blank and I am unable to think clearly when doing math work.	F	F	F	T	T	T
13	I do well on math assignments.	F	F	F	T	T	T
14	Seeing adults do well in math pushes me to do better.	F	F	F	T	T	T
15	I get depressed when I think about learning math.	F	F	F	T	T	T
16	I have been praised for my ability in math.	F	F	F	T	T	T
17	I imagine myself working through challenging math problems successfully.	F	F	F	T	T	T
18	Other students have told me that I'm good at learning math.	F	F	F	T	T	T

19	I do well on even the most difficult math assignments.	F	F	F	T	T	T
20	When I see how another student solves a math problem, I can see myself solving the problem in the same way.	F	F	F	T	T	T
21	My whole body becomes tense when I have to do math.	F	F	F	T	T	T
22	I compete with myself in math.	F	F	F	T	T	T
23	My classmates like to work with me in math because they think I'm good at it.	F	F	F	T	T	T
24	When I see how my math teacher solves a math problem, I can picture myself solving the problem in the same way.	F	F	F	T	T	T

*****Item wording changed from the original Sources of Middle School Mathematics Self-Efficacy Scale (Usher & Pajares, 2009). The original wording for each item is included below:

#2 - Seeing kids do better than me in math helps me do better in math.
#10 - I got good grades on my last report card.

References

Arbuckle, J. L. (2007). *Amos 16 user's guide.* Chicago: SPSS.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares, & T. Urdan (Eds.), *Adolescence and education, Vol. 5: Self-efficacy beliefs of adolescents* (pp. 307-337). Greenwich, CT: Information Age Publishing, Inc.

Bandura, A. (1997). *Self efficacy: The exercise of control.* New York, NY: Freeman.

Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counseling Psychology, 25,* 441-448.

Byrne, B. M. (2009). *Structural equation modeling with AMOS: Basic concepts, applications, and programming 2nd Edition.* CRC Press.

Carnegie Foundation. (n.d.). Retrieved August 2011, from The Carnegie classification of institutions of high education - updated 2010: http://classifications.carnegiefoundation.org//

Cresswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research.* Upper Saddle River, NJ: Pearson Education, Inc.

Geary, D. C. (1996). Sexual selection and sex differences in mathematical abilities. *Behavioral and Brain Sciences , 19* (2), 229-284.

Graham, S. (1994). Motivation in African Americans. *Review of Educational Research, 64* (1), 55-117.

Hailikari, T., Nevgi, A., & Komulainen, E. (2008). Academic self-beliefs and prior knowledge as predictors of student achievement in mathematics: a structural model. *Educational Psychology, 28* (1), 59-71.

Hall, M., & Ponton, M. (2005). Mathematics self-efficacy of college freshmen. *Journal of Developmental Education, 28* (3), 26-33.

Hodges, C. B. (2008). Self-efficacy, motivational email, and achievement in an asynchronous math course. *Journal of Computers in Mathematics and Science Teaching, 27* (3), 265-285.

Hodges, C. B., & Murphy, P. F. (2009). Sources of self-efficacy beliefs of students in a technology-intensive asynchronous college algebra course. *Internet and Higher Education, 12,* 93-97.

Huck, S. W. (2000). *Reading statistics and research. 3rd edition.* New York: Addison Wesley Longman, Inc.

Lent, R. W., Brown, S. D., Gover, M. R., & Nijjer, S. K. (1996). Cognitive assessment of the sources of mathematics self-efficacy: A thought-listing analysis. *Journal of Career Assessment, 4* (1), 33-46.

Lent, R. W., Lopez, F. G., & Bieschke, K. J. (1991). Mathematics self-efficacy: Sources and relation to science-based career choice. *Journal of Counseling Psychology, 38* (4), 424-430.

Lent, R. W., Lopez, F. G., Brown, S. D., & Gore, P. A. (1996). Latent structures of the sources of mathematics self-efficacy. *Journal of Vocational Behavior, 49*, 292-308.

Luzzo, D. A., Hasper, P., Albert, K. A., Bibby, M. A., & Martinelli Jr., E. A. (1999). Effects of self-efficacy-enhancing interventions on the math/science self-efficacy and career interests, goals, and actions of career undecided college students. *Journal of Counseling Psychology, 46* (2), 233-243.

Matsui, T., Matsui, K., & Ohnishi, R. (1990). Mechanisms underlying math self-efficacy learning of college students. *Journal of Vocational Behavior, 37*, 225-238.

Michaelides, M. (2008). Emerging themes from early research on self-efficacy beliefs in school mathematics. *Electronic Journal of Research in Educational Psychology, 6* (1), 219-234.

Moody, V. (2004). Sociocultural orientations and the mathematical success of African American students. *The Journal of Educational Research*, *97* (3), 135-146.

Muthen, B., & Asparouhov, T. (2010, September). Bayesian SEM: A more flexible representation of substantive theory.

National Center for Education Statistics. (2011). *Integrated Postsecondary Education Data System: College Data*. Retrieved from National Center for Education Statistics: http://nces.ed.gov/globallocator

Ozyurek, R. (2005). Informative sources of math-related self-efficacy expectations and their relationship with math-related self-efficacy, interest, and preference. *International Journal of Psychology, 40* (3), 145-156.

Pajares, F. (1997). Current directions in self-efficacy research. In M. Maehr, & P. R. Pintrich (Eds.), *Advances in Motivation and Achievement* (pp. 1-49). Greenwich, CT: JAI Press.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66* (4), 543-578.

Peters, M., Manning, J. T., & Reimers, S. (2007). The effects of sex, sexual orientation, and digit ratio (2D: 4D) on mental rotation performance. *Archives of Sexual Behavior, 36* (2), 251-260.

Peterson, P. L., & Fennema, E. (1985). Effective teaching, student engagement in classroom activities, and sex-related differences in learning mathematics. *American Educational Research Journal, 22*, 309-335.

Phelps, C. M. (2010). Factors that pre-service elementary teachers perceive as affecting their motivational profiles in mathematics. *Educational Studies in Mathematics, 75*, 293-309.

Rahman, Q., & Wilson, G. D. (2003). Large sexual-orientation-related differences in performance on mental rotation and judgment of line orientation tasks. *Neuropsychology, 17* (1), 25-31.

Schmitt, T. (2011). Current methodological considerations in exploratory and confirmatory factor analysis. *Journal of Psychoeducational Assessment, 29* (4), 304-321.

Schunk, D. H., & Pajares, F. (2002). The development of academic self-efficacy. In A. Wigfield, & J. Eccles (Eds.), *Development of achievement motivation* (pp. 15-31). San Diego, CA: Academic Press.

Smittle, P. (2003). Principles for effective teaching in developmental education. *Journal of Developmental Education, 26* (3), 10-16.

Spence, D., & Usher, E. L. (2007). Engagement with mathematics courseware in traditional and online remedial learning environments: Relationship to self-efficacy and achievement. *Journal of Educational Computing Research, 37* (3), 267-288.

Stevens, T., Olivarez, A., Lan, W. Y., & Tallent-Runnels, M. K. (2004). Role of mathematics self-efficacy and motivation in mathematics performance across ethnicity. *The Journal of Educational Research, 97* (4), 208-221.

Usher, E. L., & Pajares, F. (2009). Sources of self-efficacy in mathematics: A validation study. *Contemporary Educational Psychology, 34*, 89-101.

Usher, E. L., & Pajares, F. (2008). Sources of self-efficacy in school: Critical review of the literature and future directions. *Review of Educational Research, 78* (4), 751-796.

Wadsworth, L. M., Husman, J., Duggan, M. A., & Pennington, M. N. (2007). Online mathematics achievement: Effects of learning strategies and self-efficacy. *Journal of Developmental Education, 30* (3), 6-14.

Warner, R. M. (2008). Applied statistics: From bivariate through multivariate techniques. Thousand Oaks, California: Sage Publications, Inc.

Zeldin, A., & Pajares, F. (2000). Against the odds: Self-efficacy beliefs of women in mathematical, scientific, and technological careers. *American Educational Research, 37* (1), 215-246.

Tonja Motley Locklear

Date of Birth: December 25, 1969
Place of Birth: Danville, Virginia

EDUCATIONAL EXPERIENCE

Wake Forest University Winston-Salem, North Carolina	M.A., Mathematics: 1993 Under the direction of Dr. Richard Carmichael
Averett University Danville, Virginia	B.S., Mathematics: 1991 Secondary Teaching Licensure

PROFESSIONAL EXPERIENCE

2000 – *present*	Assistant Professor of Mathematics **Averett University**, Danville, Virginia
1996 – 2000	Secondary Mathematics Teacher **George Washington High School**, Danville, Virginia
1994 – 1996	Alternative High School Mathematics Teacher **Opportunity School**, Danville, Virginia
1993 – 1994	Eighth Grade Mathematics Teacher **East Lee Middle School**, Sanford, North Carolina

SCHOLASTIC AND PROFESSIONAL HONORS

Department of Mathematics Graduate Assistantship, Wake Forest University, 1991-1993

Pi Mu Epsilon, Mathematical Honor Society, Wake Forest University, 1992

Alpha Chi, National Honor Society, Averett University, 1989

Phi Eta Sigma, National Honor Society, Averett University, 1988

PROFESSIONAL PUBLICATIONS

Hudson, T. (2009). Slaying the Mathematical Demon. *Averett Journal: 150th Anniversary Edition, 27*, pp. 73-77.

Locklear, T. (2011). Culturally Relevant Teaching of Mathematics for the 21st Century. *Averett Journal*, *29*, pp. 41-46.