The University of Southern Mississippi
The Aquila Digital Community

Dissertations

Spring 5-2015

The Relationship Between Students' Applied Mathematics Skills and Students' Attitudes Towards Mathematics

Taylor Andrew Kilman
University of Southern Mississippi

Follow this and additional works at: https://aquila.usm.edu/dissertations

Part of the Science and Mathematics Education Commons

Recommended Citation

Kilman, Taylor Andrew, "The Relationship Between Students' Applied Mathematics Skills and Students' Attitudes Towards Mathematics" (2015). *Dissertations*. 54.
https://aquila.usm.edu/dissertations/54

The University of Southern Mississippi

THE RELATIONSHIP BETWEEN STUDENTS' APPLIED MATHEMATICS

SKILLS AND STUDENTS' ATTITUDES TOWARDS MATHEMATICS

by

Taylor Andrew Kilman

A Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

May 2015

ABSTRACT

THE RELATIONSHIP BETWEEN STUDENTS' APPLIED MATHEMATICS

SKILLS AND STUDENTS' ATTITUDES TOWARDS MATHEMATICS

by Taylor Andrew Kilman

May 2015

Mathematics is a subject with which many students struggle. It has been noted that students' attitudes towards mathematics can often affect their performance in related courses. The goal of this research is to explore the relationship between students' basic applied mathematics skills and students' attitudes towards mathematics. That is, do students, as they learn how to use mathematics in the real world, tend to develop a more favorable outlook towards mathematics? Or, on the other hand, do the attitudes towards mathematics of students remain unaffected as their ability to use mathematics in the real world increases? The current research seeks to clarify these propositions in an effort to improve mathematics instruction by providing educators with a better understanding of students' attitudes towards mathematics.

Multiple linear regression analysis found that attitude toward mathematics was indeed significantly related to students' basic applied mathematics skill. Attitude toward mathematics explained 29.7% of the variance observed in basic applied mathematics skill. Attitudinal subscales were also analyzed. Student self-confidence and motivation were both significant predictors of basic applied mathematics skill. In a separate analysis, attitude toward mathematics was found not to be significantly related to mathematical achievement in the college classroom.

The University of Southern Mississippi

THE RELATIONSHIP BETWEEN STUDENTS' APPLIED MATHEMATICS

SKILLS AND STUDENTS' ATTITUDES TOWARDS MATHEMATICS

by

Taylor Andrew Kilman

A Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

Approved:

Dr. Sherry Herron
Committee Chair

Dr. Melinda Gann

Dr. Kyna Shelley

Dr. Richard Mohn

Dr. Karen S. Coats
Dean of the Graduate School

May 2015

DEDICATION

To FSM, whom without, this would not have been possible.

ACKNOWLEDGMENTS

The writer would like to thank the dissertation director, Dr. Sherry Herron, and the other committee members, Dr. Kyna Shelley, Dr. Melinda Gann, and Dr. Richard Mohn, for their advice and support throughout the duration of this project.

TABLE OF CONTENTS

LIST OF TABLES

Table

CHAPTER I

INTRODUCTION

Mathematics is omnipresent in our modern day world. Paradoxically, however, it is not seen nearly as much as it is used. Instead, it usually exists in the background, providing a foundation for all of the technology that drives our modern day world. Without mathematics, we could not enjoy our I-phones, tablets, televisions - not to mention the internet. It seems odd, then, that mathematics would be a subject with which many students struggle. But year after year, this reality remains unchanged. A recent national survey of college transcripts found that mathematics classes had twice as many F and D final course grades when compared to other courses (Hacker, 2012). The latest results from the Program for International Student Assessment (PISA) revealed that the United States scored below average when compared to other developed countries and placed behind 26 others in the ranking (OECD, 2012). Even though the United States scored below average on the PISA assessment, mathematics is a very important part of our everyday lives. A functional knowledge of mathematics *and* a corresponding positive disposition toward the use of mathematics is imperative for citizens to make informed decisions about their daily lives (Wilkins & Ma, 2002). Many researchers have found a relationship between students' attitudes towards mathematics and student achievement in mathematics (Ma & Kishor, 1997). One possible way to improve students' attitudes towards mathematics may be to provide authentic instruction. That is, teach mathematics in the context of everyday life. If students understand the usefulness and importance of mathematics in our modern world, their attitudes towards mathematics may in turn improve, which could ultimately lead to better achievement outcomes.

Statement of the Problem

The goal of this study is to explore the relationship between students' knowledge of applied mathematics and students' attitudes towards mathematics. This would in turn inform educators on ways in which instruction and curriculum can be modified to favorably affect students' attitudes towards mathematics. Since a positive link between students' attitudes toward mathematics and students' achievement in mathematics has already been demonstrated (Ma & Kishor, 1997), changes in curriculum that positively affect students'' attitudes may in fact increase academic performance.

Purpose of the Study

The purpose of the study is to answer the following research questions:

1. What is the relationship between student's knowledge of applied mathematics and students' attitudes towards mathematics?

2. If a significant relationship does indeed exist between students' applied knowledge of mathematics and students' attitudes towards mathematics, does this relationship affect student achievement in mathematics?

Rationale

The improvement of students' attitudes towards mathematics is one of the keys to improving student achievement in mathematics. Unfortunately, negative attitudes towards mathematics abound. Phrases such as "I hate math" and "I am terrible at math" are frequently heard in mathematics classrooms and beyond. But what if this was not the case? Suppose for a moment that the majority of students understood the great utility of mathematics and perhaps had a more favorable outlook towards mathematics as a result. The purpose of this study is to see if there is any link between students' applied

mathematical skills and their attitudes towards mathematics. If these two constructs are seen to be tethered, then mathematics educators may in turn focus more attention on the applied side of mathematics instruction in an effort to have some effect on the attitudes of students towards mathematics. Furthermore, another goal of this study is to see if either of these constructs are related to achievement in mathematics. If applied mathematics skill can be linked to attitude towards mathematics, and if attitude towards mathematics is linked to achievement, a path to increasing mathematical achievement may arise.

The subject of mathematical problem solving is especially timely considering the fact that 46 states and the District of Columbia have adopted the Common Core State Standards (CCSS). These are standards that outline goals for students across grade levels and subjects. The mathematics standards place heavy emphasis on problem solving. Referred to as "modeling," this process links everyday situations to appropriate mathematical analyses. Modeling lessons are dispersed throughout all topics, showing students how to use mathematics outside of the classroom.

Since the goal of this research is to examine the relationship between students' problem solving skills and students' attitudes towards mathematics, the results of this research are particularly pertinent. If it turns out that there indeed exists a positive relationship between the two aforementioned variables, then one would expect to see a rise in positive student attitudes towards mathematics, considering problem solving is such as large emphasis of the CCSS. This research could bolster the position of the CCSS by showing that its emphasis on problem solving is not only useful for student enrichment but also for improving students' attitudes towards mathematics. Furthermore,

as outlined by Ma and Kishor (1997), improved student attitudes generally lead to higher achievement in the mathematics classroom.

Definition of Terms

Key phrases used throughout the current research are defined as follows:

1. Attitude: Opinions, thoughts, and feelings towards mathematics

2. Achievement: The overall average earned by a student in a mathematics course

3. Basic applied mathematics skill: The ability to use mathematics to solve common problems encountered in everyday life

4. Real-world mathematics: Mathematical concepts that are used to solve problems in everyday life

5. Problem solving: The process of solving a problem where the solution method is not known in advance (NCTM, 2000)

6. Authentic mathematics: An umbrella-term for describing a category of teaching methods, the goal of which is to explicitly give in-class instruction targeted meaningful, and relevant real-world context in order to provide the possibility of a deeper level of understanding for students.

CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this study is to explore the relationship between students' attitudes towards mathematics and students' basic applied mathematics skill. To this end, several different arenas of relevant literature will be investigated in order to provide context for the current study. First, a brief history of mathematics education in the United States will be outlined. Second, several examples of problem-based curriculum and research into these curriculum will be examined. Next, general educational research dealing with problem-based instruction will be reviewed. Lastly, the current literature regarding students' attitudes toward mathematics will be outlined.

A Brief History of Problem-Based Mathematics Education

Mathematics education in the United States has been in flux for some time now. For over a century there has been a fight between progressives and traditionalists regarding how mathematics should be taught to American children. The traditionalists contend that systematic teaching and practice are the keys to students' success in mathematics, while the progressives promote a more child-centric and problem based approach (Klein, 2007). The longstanding controversy received the label "math wars" and even garnered attention from the United States cabinet when the Secretary of Education Richard Riley asked both sides for calm at the annual Joint Mathematics Meeting of the Mathematical Association of America and the American Mathematical Society (Schoenfeld, 2004).

One major tenet of the progressive mathematics education camp is authentic instruction. Authentic instruction is education that provides students with feasible, real

world applications of the covered material similar to situations that students may encounter in their everyday lives (Ormrod, 2006). Authentic instruction is problem-based. That is, the material is taught via real world examples.

In 1980, the National Council of Teachers of Mathematics (NTCM) released its *Agenda for Action*, a game plan for mathematics in the coming decade, which declared that problem solving "should direct the effort of mathematics educators," and the mathematical competence of the nation is measured on how well citizens can use mathematics in their everyday lives (Davison & Mitchell, 2008). The group went on to explain that this concept should not be taken to the extreme so that mathematics is taught and seen as simply a complement to applications. Mathematics still needs to be taught as a cohesive and unified field of knowledge. This new plan, however, placed less emphasis on rote memorization of simple facts and placed more emphasis on problem solving and inquiry.

But change is slow to happen. Schoenfeld, (2004) comments that although mathematical problem solving was vehemently called for in the early 1980s, little was actually changed in the mathematics textbooks. For instance, students, instead of being presented with a set of typical addition problems, would be presented with a set of problems that read along the lines of "Sue had 8 oranges. She gave 3 to Bill. How many oranges does Sue now have?" Problem solving sections were also added to textbooks, but mainly as an afterthought to an existing curriculum. Schoenfeld (2004) states that this superficial change was due mainly to the realities to the textbook adoption process – where Texas, New York, and California, because of their extreme share of the textbook market, dictate which books are used in the American classroom.

After yet another decade of gloomy performance by American mathematics students in the 1980s, the National Research Council published two reports in an effort to bring light to the dismal situation. *Everybody Counts* (1989) essentially called for the reform of mathematics education in the United States, stating that "America needs to reach a consensus on national standards for school mathematics" (p. 46). *A Challenge of Numbers* detailed some of the more troubling statistics regarding students' underachievement in mathematics (Madison & Hart, 1990). The low rankings of the United States in regard to worldwide mathematics education had been known at least since 1967 when the first International Evaluation of Achievement report was released (Davison & Mitchell, 2008). Perhaps the most notable fact of *A Challenge of Numbers* was the failure rate of mathematics students. Madison and Hart (1990) calculated the failure rate of mathematics students at over fifty percent for the general student population grade nine and above and much higher for certain minority sub-populations.

In 1989, NCTM released its *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989). The main goal of this document was to "create a coherent vision of what it means to be mathematically literate" in our modern world and lay a foundation for the reformation of school mathematics in the United States (NCTM, 1989, p. 1). The authors outlined broad societal goals such as a mathematically literate workforce, lifelong learning, and an informed electorate (NCTM, 1989). The *Standards* also listed mathematical reasoning and problem solving as main goals for mathematics education moving forward. The overarching theme of the report was constructivism – that is, student centered instruction that actively involves the student in the educational process.

The 1990s proved to be a period of strife in the world of school mathematics curriculum. This conflict between traditional mathematics educators and progressive mathematics educators has come to be known as the "math wars" (Schoenfeld, 2004). Problem solving is not the central tenet of the progressive mathematics education agenda, but it is a very important corollary. Therefore problem solving in the mathematics classroom was dependent on the outcome of these "math wars." Textbooks began to be written with the *Standards* in mind to include more items to encourage a holistic understanding of mathematics at the expense, as critics charged, of basic skills practice (Klein, 2007). Major markets, such as California, adopted new textbooks which followed the *Standards* and, as previously discussed, the rest of the states followed.

In 2000, NCTM released a major update to their original *Standards.* This document, *Principles and Standards for School Mathematics*, again set forth a framework for mathematics education reform. It outlined standards for each grade level and fairly specific expectations for what each standard meant in the classroom. Two of the ten standards dealt with problem based instruction. Problem solving itself is a standard promoted by NCTM which, according to the *Principles and Standards,* should be taught at all grade levels. NCTM also recommends that reasoning and mathematical proof, a topic closely related to problem solving, be stressed at all grade levels.

The National Commission on Mathematics and Science (2000), appointed by Secretary of Education Richard Riley and led by John Glenn found that mathematics instruction had not evolved into what many reformers had envisioned. Unfortunately, American Education remained essentially the same as it had been for the past several generations. In the report *Before It's Too Late*, the authors also remarked that United

States is still remarkably far from the lead position in the world as far as mathematics achievement is concerned. The authors suggested on many occasions that inquiry-type instruction is the prudent instruction method to use in the mathematics classroom instead of the repetitive, predictable mathematics of prior generations.

In the 2000s, much of the educational debate centered about the legislation No Child Left Behind (NCLB). The improvement of student mathematical performance in the United States was one of the main goals of NCLB. The era of high-stakes testing shifted much of the debate about mathematics curriculum to the topic of testing. After a decade of much controversy, the Obama administration began to allow states exemptions from the most onerous requirements of NCLB in exchange for states creating a detailed and coherent plan for improving student performance (Rich, 2012). By January 2013, forty-six states had voluntarily adopted the Common Core State Standards (CCSS). Somewhat similar to the *Principles and Standards*, the CCSS outline specific topics to be discussed in the classroom at different grade levels. The CCSS, however, are not textbook specific. Rather, the CCSS enumerate standards for mathematical practice for all grade levels. The standards greatly support problem solving in the classroom. These include the ideas that students should reason abstractly and quantitatively, model with mathematics, and use appropriate tools strategically. The jury is still out on how effective the CCSS will be in the classroom. With the majority of states onboard, results regarding the efficacy of the CCSS should begin to flow in over the next several years.

Problem-Based Mathematics Curriculum

Constructivism is a learning theory that proposes that students construct knowledge by connecting new knowledge to prior knowledge through new individual or

social experiences. A major tenet of constructivism is that students are curious and natural learners if placed in a conducive environment. Furthermore, the learning process has been described as a highly social process (Vygotsky, 1978). In the classroom, this translates into the notion that students should be actively involved in the learning process – not just passively listening as a lesson is being taught. Direct instruction, on the other hand, imagines students as passive bystanders in the classroom. That is, teachers have a knowledge which they simply pass along to learners.

Problem-based instruction is a teaching technique that stems from the constructivist learning theory. It is a form of teaching where students are presented with a real-world problem and then given the time and opportunity to solve that problem in order to discover a new concept or practice a newly learned concept. The process of solving an authentic, real-world problem is the avenue for new mathematical concepts to be presented. Hiebert et al. (1996) proposed that the mathematics classroom should be "problematic." That is, based on problem solving. Students should be allowed to inquire – to wonder why things are the way they are – and to resolve the incongruities they encounter (Hiebert et al., 1996). Those same authors argue that a "problematic" mathematics classroom is well suited to engage students, shows students how mathematicians solve mathematics, and makes mathematics useful and relevant to students. This problem-based process can be completed with varying degrees of guidance from the teacher. The role of the teacher is to help students along their own paths to find solutions to posed problems. With this type of instruction, the correct mathematical solution is not the only goal. Students also learn valuable skills such as critical thinking, estimation, and mathematical communication (Petric, 2011).

One of the most successful reform curricula is the *Connected Mathematics Project* – the CMP. The CMP is a middle school curriculum developed by the University of Michigan. The key characteristic of the CMP is that student learning is facilitated via a problem-based approach. That is, students discover mathematical concepts primarily through examining real world problems (Clarkson, 2001). The CMP was first developed in 1995 – with the latest revision published in 2014.

Several researchers have examined the effects of the CMP on general mathematical achievement, specific mathematical problem solving, and the achievement gap between minority and majority students. Clarkson (2001) examined 700 students and found that there was no significant difference on state achievement tests between students who completed three years of *Connected Mathematics* and those students who were enrolled in traditional mathematics courses over the same three years. However, other differences between the groups were observed. For instance, the students in in CMP fared better on problem solving assessments – not surprising since this was a mainstay of their mathematics classroom (Clarkson, 2001). The author also noted a reduction in the achievement gap between white students and African American students in the CMP – when compared to similar students in traditional mathematics classrooms. Finally, through qualitative analysis, Clarkson (2001) observed that students in the CMP expressed higher levels of satisfaction with their mathematics curriculum than did the students with traditional curriculum. In summary, while the *Connected Mathematics Project* did not lead to significant gains in overall mathematical achievement as measured by state achievement tests, the reform curricula did lead to several other worthwhile gains in the mathematics classroom.

Lappan, Fey, Fitzgerald, Friel, and Phillips (1999) drew conclusions similar to Clarkson (2001). The authors examined a one year window of *Connected Mathematics* implementation and compared that to a control group which used a traditional mathematical curriculum. The authors found that no significant differences in overall achievement existed between the group exposed to *Connected Mathematics* and the group using traditional mathematics curriculum. Just as with Clarkson (2001), however, significant differences were observed on problem-solving evaluations. This of course is logical since problem solving is the major tenet of *Connected Mathematics.*

Cain (2002) examined the effects of the CMP on middle schools in Lafayette Parish school district in Louisiana. The author considered the 1998-1999 and 1999-2000 school years and compared the performance of schools that used the CMP versus schools that used the status quo, traditional mathematics curriculum. Only some of the schools had implemented the CMP curricula, so performance could be compared to other similar schools in the district that had not implemented the CMP curricula. Both quantitative and qualitative data were collected by the researcher. The researcher found that on average, scores on the Iowa Test of Basic Skills (ITBS) were higher in schools that implemented the CMP when compared to school that used traditional curriculum. In the first year of the study, sixth grade students who used the CMP curricula score on average 16% higher than their counterparts in non-CMP classrooms. Seventh grade students in CMP classrooms also scored higher than their peers in non-CMP classrooms in the first year – to the tune of 9% higher. The differences also existed during the second year of the study, although the differences did decrease slightly. The researcher also considered differences between groups in regard to the Louisiana Educational Assessment Program (LEAP) test.

Similar to his previous findings, the author found that passing rates on the LEAP test were much higher for CMP students when compared to non-CMP students. For the first year studied, the passing rate on the LEAP test of CMP students was 86% while the passing rate of non-CMP students 70%. A 10% difference was found between the groups (in favor of the CMP curricula) during the second year of the study.

Cain (2002) also collected data regarding the experiences of both students and teachers in the CMP-oriented classrooms. Twenty-eight teachers and 300 students were surveyed as a part of the study. Overwhelmingly, the teachers responded positively to the CMP curricula. The teachers expressed opinions that on average students were becoming better problem solvers, that they in general favored the CMP over past traditional curriculum, and that the CMP had led to the teachers themselves having a deeper understanding of the mathematical subject matter they taught (Cain, 2002). Many instructors also expressed that the CMP curricula was more challenging that the old, traditional curriculum and that the CMP training they received was essential to the success of the program (Cain, 2002). Students also reacted favorably to the advent of the CMP curricula. The researcher asked students questions regarding their preference of curriculum (traditional vs. CMP), if the CMP curricula was helping them become better problem solvers, if the CMP curricula helped them understand mathematics better, and if the CMP curricula made them "think more" than their old curriculum. As with the surveyed teachers, the majority of students indicated that the CMP was indeed better overall than their previous math curriculum, that the CMP was helping to make them better problem solvers, and the CMP curriculum made them "think more" (Cain, 2002).

The researcher demonstrated that from both attitudinal and performance perspectives, the CMP was a success for the Lafayette Parish school district.

In 2003, the developers of *Connected Mathematics* released the CMP Research and Evaluation Summary. This document outlined many success stories of *Connected Mathematics* curriculum having a positive impact on school districts across the United States. Significant increases in student achievement on state tests were seen public school districts such as Plano, Texas, Ann Arbor, Michigan, and many more (Bray, 2005). Sometimes statewide achievement scores were similar between students enrolled in traditional mathematics and students enrolled in *Connected Mathematics,* but it was commonly the case that students' problem solving skills were boosted by being exposed to the *Connected Mathematics* curriculum (Bray, 2005).

Another reform curriculum to emerge after the NCTM released its *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989) was Core-Plus mathematics. Core-plus is a National Science Foundation supported mathematics curriculum for high school students that embraces the NCTM's *Principles and Standards.* This particular curriculum is a great departure from traditional high school mathematics in that each grade is not taught one specific subject (e.g. algebra *or* geometry *or* pre-calculus). Instead, Core-plus mathematics integrates many different subjects into each grade level. Each level includes topics from algebra, geometry, probability and statistics, and discrete mathematics. Furthermore, the curriculum places a strong emphasis on real world mathematics problem solving and authentic mathematics education - therefore deemphasizes algorithmic manipulation (Harwell, Medhanie, Post, Norman, & Dupuis, 2012).

As with any new curricula, there are proponents and opponents. Proponents of integrated curricula such as Core-Plus mathematics point out that integrated curricula emphasizes connections between different areas of mathematics, fosters much needed problem solving skills, and generally underscores how mathematics can be used in everyday life (Grouws et al., 2013). On the other hand, detractors of this type of reform mathematics often complain that this type of curriculum wastes too much time reviewing past material, lacks a proper emphasis on basic mathematical skills, and is a burden to students who transition to and from another district which uses traditional mathematics curriculum (House, 2003; Usiskin, 2003). Of course, further complaints are often made regarding teacher training and preparedness for the implementation of new curriculum. As with any reform effort in the mathematics classroom, there are people on both sides who vehemently support or oppose the implementation of change. Fortunately, enough time has passed and several researchers have examined the effectiveness of integrated curriculum such as Core-Plus which may help to settle the debate between traditional curriculum and reform-type curriculum.

Harwell et al. (2012) conducted a research study to examine the preparedness of students who were enrolled in at least three years of Core-Plus mathematics versus students who had been enrolled in a traditional high school mathematics curriculum over the same time period. The researchers sample consisted of 1,588 students at a large, Midwestern public university who had taken at least two college mathematics courses of difficulty beyond pre-calculus. The authors concluded that there were no significant differences in college mathematical achievement between students who had taken traditional mathematics courses in high school versus those students who had taken Core-

Plus mathematics courses in high school. In addition, the authors examined if there were any significant differences when students were STEM majors in college. The authors found that even when students were committed to mathematically intense college majors in STEM fields, there were no statistically significant differences in mathematical achievement between students who had previously been enrolled in Core-plus mathematics and traditional mathematics. Although not necessarily positive for Core-Plus curriculum, these results demonstrate that reform mathematics such as Core-Plus do indeed adequately prepare students for college mathematics.

Grouws et al. (2013) conducted a research study which aimed to examine the differences between students who were taught mathematics in a classroom which used integrated curriculum and those students who were taught mathematics in a classroom which used traditional curriculum. Specifically, researchers compared students using Core-plus Course 1 with students who studied strictly Algebra 1. Most of the traditional classrooms used *Glencoe Algebra 1*. The researchers compiled a sample of 2,162 students from 10 schools across five states. The researchers made sure to accounts for demographics such as socio-economic status, student tracking policies, class length, technology policies, and other school characteristics. The researchers used three different measures of student achievement at the end of year. The first was a tool developed by the researchers that tested concepts common to both the traditional mathematics curriculum and Core-plus curricula. The second instrument was a researcher-generated scale that measured students' problem solving abilities. The third instrument was the Iowa Test of Educational Development - Mathematics: Concepts and Problem Solving. The researchers used hierarchical linear modeling and found that students enrolled in the

classrooms which used Core-Plus score significantly higher on all three instruments when compared to students enrolled in classrooms which used traditional mathematics curriculum. The researchers observed effect sizes of 0.38, 0.45, and 0.17 on the first, second, and third scales, respectively. The authors conclude that their research demonstrates both the value of integrated mathematics curriculum such as Core-Plus and also that curriculum choices make profound differences in the ways students learn and achieve in the mathematics classroom.

The aforementioned curricula have been used in mathematics classrooms around the country since the mid-1990s, with varying degrees of success. As outlined earlier, some samples demonstrated both quantitative and qualitative student gains. On the other hand, some researcher found that the new reform curriculum did not alter student performance. Admittedly, there are many different variables in play here and more comprehensive, long-term studies will be required to completely evaluate the effectiveness of such programs.

General Research Regarding Problem-Based Mathematics

Since the advent of the mathematics reform movement in the early 1990s, researchers attempted to document and quantify the effects that reform mathematics has had in the classroom. As previously discussed, much of the mathematics reform movement has generally centered around constructivism and specifically led to problem-based, student centered mathematics instruction. These practices have been implemented with varying levels of success in elementary, middle, high schools across the nation. To a lesser extent, these practices have been adopted in the post-high school educational setting.

Wood and Sellers (1996) followed a group of second and third graders during the early days of the 1990s mathematics reform movement. Six classrooms implemented a problem-based mathematics curriculum. The study took place over the span of two years and performance was compared between students who were enrolled in the reform class for one year with the students who were enrolled in the reform class for two years. Performance of these students was also compared to their counterparts who were not enrolled in a reform-oriented classroom, but were enrolled in a traditional textbook-based classroom. The researchers found that after two years in the problem-based mathematics classroom, reform students outperformed their non-reform counterparts on both an arithmetic test and the Indiana Sequential Test of Educational Progress (mathematics sub-test). These two instruments measured computational fluency and conceptual understanding, respectively. An attitudinal questionnaire administered by the researchers also found that students in the reform-oriented classrooms developed significantly more positive beliefs regarding mathematical problem solving, when compared to non-reform students. The authors comment that these results demonstrate the dichotomy that exists between the main beliefs regarding mathematics education. One tradition is that mathematics is a static discipline that is mastered by students following directions from their instructors while the other tradition (inquiry or problem based mathematics) views learning mathematics as a creative task where solutions are devised by the students themselves (Wood & Sellers, 1996).

Randhawa, Beamer, and Lundberg (1993) reached the conclusion that mathematics classroom needs "explicit links to everyday application of mathematics. The authors used structural equation modeling to help explain mathematical achievement. In

their model, students' attitudes towards mathematics and students self-efficacy in mathematics were the latent variables. The authors found that both students' attitudes toward mathematics and' self-efficacy were directly linked to mathematical achievement. Furthermore, students' mathematical self-efficacy was also a mediating variable between students' attitudes toward mathematics and students' mathematical achievement. The authors suggest that students' self-confidence (and consequently, self-efficacy) may indeed be boosted by creating a classroom environment rich with strong ties to everyday mathematical applications where students can learn to transfer their classroom learning to the real world. This suggestion echoes the contemporaneous *Curriculum and Evaluation Standards for School Mathematics* which also calls for a heavy emphasis on learning mathematics which is useful students' everyday lives (NCTM, 1989).

Portal and Sampson (2001) explored how problem-based instruction was related to students' motivation and achievement in the high school mathematics classroom. The study was conducted at a suburban, middle class high school and the sample consisted of 1460 students and 76 teachers. The authors found that when teachers used a problem-based instructional strategy that students exhibited more positive behaviors and that achievement was modestly increased.

Ziegler and Yan (2001) explored how different instructional methods affected student achievement using data from the National Education Longitudinal Study. Specifically, they examined how different instructional strategies affect students' achievement in respect to problem solving. The authors found that a constructivist approach in the mathematics classroom was the most effective way to teach problem solving skills and had the greatest effect on students' problem solving achievement.

Constructivist teaching strategies like inquiry-based instruction and group work fostered students' problem solving skills to a greater extent than did traditional teaching strategies such as direct instruction.

Zahorik (1996) explored how teachers attempt to make the classroom an engaging environment for students. The sample consisted of 65 elementary and secondary school teachers who were enrolled in a graduate course emphasizing constructivist learning. The researcher searched for commonalities among the various ways teachers attempted to create a rich learning experience for their students. Two of the themes the researcher found related to problem-based instruction. First, the author found that hands-on activities were a good way to engage students. The author gives the example of having students in a classroom determine the sugar content of a pack of chewing gum. The author also lists the use of practical tasks as a way of stimulating student interest. Practical tasks refer classroom activities that have utility outside of the school classroom (Zahorik, 1996). Using problem-based instruction to show students how to use mathematics in their everyday life is an example of a practical task, according to Zahorik's definition. One example of such an exercise is an activity where the goal is for students to discover how to compute the unit price of a food item. This is a mathematical task which has great utility outside of the mathematics classroom – especially in the grocery store!

Boaler (1998) conducted a three-year longitudinal study that explored the relationship between instructional strategy and student achievement. The author studied two high schools in working class areas of the United Kingdom. The study consisted of approximately 300 students who were followed over the course of three years. One of the

schools used traditional teaching methods in the mathematics classroom. That is, direct instruction (lecture) was the sole instructional strategy employed by teachers. The second school used a constructivist approach in the mathematics classroom where open-ended projects were a main staple. Authentic activities, those which mimic real-world situations, were used heavily and always in the introduction of new material. The author used qualitative methods such as case studies but also used a variety of quantitative assessments to gauge student achievement and attitudes. Boaler found that the traditional instructional methods of one school were "completely ineffective in preparing students for the real world" (Boaler, 1998 p. 60). Students who experienced the problem-based instruction, on the other hand, were able to achieve higher grades in both applied and regular assessments. The students who completed the problem-based curriculum also reported markedly higher attitudes towards mathematics, when compared to the students enrolled in the traditional curriculum.

Riordan and Noyce (2001) compared the mathematical achievement of students enrolled in reform, inquiry-based mathematics classes with their counterparts enrolled in traditional mathematics courses. The sample included both eighth and fourth grade students enrolled in Massachusetts public schools. The researchers collected data from schools that used reform curricula such as *Everyday Mathematics* and *Connected Mathematics* and schools that used traditional mathematics curricula. The schools and classes were similar on a demographic level. The researchers found that students in mathematics classrooms that employed reform curricula scored on average several points higher on the state standardized tests than did students in traditional mathematics classrooms. The authors also investigated the topic for different strands of the

Massachusetts mathematics standards and different student subpopulations. In both instances, the researchers found significant gains in the scores of the students who used the reform, inquiry-based curricula.

Curtis (2006) found qualitative evidence that college algebra students in a reform-oriented classroom reported greatly improved attitudes towards mathematics. The author found that instructional strategies like group activities, classroom discussions, and problem-based learning help to relieve classroom anxiety, improve mathematical confidence, and increased student enjoyment. The author also used quantitative methods and found a statistically significant relationship between the aforementioned reform-type activities (group discourse, group activities, problem-based learning) and students enjoyment of mathematics.

<div align="center">Students' Attitudes Toward Mathematics</div>

A fair amount of past educational research has dealt with the issue of students' attitudes towards mathematics. Many authors have examined how attitudes towards mathematics are affected by demographic constructs such as race or gender. Others, as previously outlined, have examined the effects of different instructional methods on students' attitudes towards mathematics. The focus of this section will be on the general relationship between students' achievement and students' attitudes toward mathematics.

Schiefele and Csikszentmihalyi (1995) conducted a study in two Chicago suburban high schools which examined the effect among several different variables on mathematical achievement. They considered mathematical interest, motivation, mathematical ability, and the quality of the experience while doing mathematics. While the researchers never explicitly considered students' attitudes toward mathematics, three

of the four independent variables were indeed very closely related to students' attitudes

toward mathematics (motivation, mathematical interest, and quality of experience). The

sample consisted of 108 students who had been selected by their teachers as being

talented in one of several subject areas (athletics, art, music, science, or mathematics).

Using regression analysis, the researchers found that mathematical interest was a

significant predictor or mathematical achievement. Furthermore, the authors point out

that, although it cannot be completely determined in there study, it does not appear to be

the case that past mathematical achievement is solely responsible for higher student

interest in mathematics. This was due to the fact that the researchers had access to each

participant's prior year PSAT mathematics scores. The researchers also found that

mathematical interest was significantly related to the quality of the experience in the

mathematics classroom. That is, higher levels of mathematical interest were correlated

with qualities such as better student moods in the mathematics classroom, higher levels of

achievement motivation, self-esteem, and other positive constructs. The researchers note

the importance of a positive classroom experience and remark that a positive classroom

experience is a desired outcome in its own right, alongside other desirable outcomes such

as high levels of achievement (Schiefele & Csikszentmihalyi, 1995). It follows that a

worthwhile endeavor would be to aim to increase levels of student interest in

mathematics so that an overall higher quality student experience may be achieved in the

mathematics classroom.

The *Longitudinal Study of American Youth* is a treasure trove of nationwide

student data regarding students' science and mathematical growth and achievement. It

was collected over six years beginning in 1987. Wilkins and Ma (2002) used these data

and hierarchical linear modeling to devise a model of students' mathematical growth in middle and high school. At the student level, the researcher tested both students' mathematics self-concept and students' educational aspirations as predictors of mathematical achievement. The authors defined mathematics self-concept as a construct similar to attitude toward mathematics. Mathematics self-concept aimed to capture how students felt towards mathematics and their ability to understand and use mathematics (Wilkins & Ma, 2002). The authors found that at the middle school level, students with a higher math self-concept experienced statistically significant higher rate of academic growth than their counterparts with a lower math self-concept. At the middle school level, educational aspirations was not a significant predictor of student achievement growth. At the high school level, however, the significance of the predictors was reversed. Math self-concept was no longer a significant predictor of mathematical achievement growth whereas educational aspiration was a statistically significant predictor. The authors theorize that this is likely due to the fact that college or employment aspirations are greatly stressed at that age so mathematics is seen as an important tool for those goals, not for personal enrichment reasons (Wilkins & Ma, 2002).

Other researchers have used factor analysis to demonstrate that student' attitudes towards mathematics affect student achievement in mathematics. Singh, Granville, and Dika (2002) created a structural model to help explain the relationship between students' attitudes towards mathematics and achievement. Their sample consisted of a nationally representative sample of over 3,000 eighth grade students. The authors used students' attitudes, motivation, and time spend on task to predict mathematical achievement.

Although time spent on task was the greatest predictor, motivation and attitudes towards mathematics also proved to be statistically significant indicators of student achievement in mathematics. Attitude toward mathematics was shown to have both direct and mediating effects on mathematical achievement. For instance, attitude toward mathematics affected time spent on academic tasks, which in turn affected mathematical achievement.

Reynolds and Walberg (1992) devised a structural equation model as well to help explain student achievement in mathematics. Their model took a more holistic, inclusive approach – including variables in their model such as home environment, peer group pressures, exposure to mass media, and instructional time. The authors used a sample of 2,553 tenth grade students from the Longitudinal Study of American Youth data set. The researchers discovered several interesting results. First, mathematical achievement and students' attitudes towards mathematics had a reciprocal relationship. That is, students' attitudes towards mathematics led to higher achievement but it is also the case that higher levels of achievement precipitated more positive student attitudes. The researchers did note, however, that the evidence seems to indicate that the achievement has a stronger influence on attitudes rather than the reverse situation. This indicated that as students tend to have a more positive attitude towards learning and using mathematics as they perform better in their respective mathematics course. The researchers found that instructional quality, instructional time, and prior achievement had direct effects on students' attitudes towards mathematics. A very interesting result from this research was the fact that motivation and home environment had significant indirect effects on students' attitudes. The authors surmise that home environment and motivation play a larger role in

attitudinal development of high school student than other factors such as instructional time or course content.

Oftentimes researchers view the relationship between attitude towards mathematics and mathematical achievement in a unilateral manner. That is, attitudes are usually thought to affect achievement outcomes. Ma (1997) devised a structural equation model to examine the reciprocal relationship between attitude toward mathematics and achievement in mathematics. The sample consisted of 1,044 Dominican high school seniors. Two national achievement tests were used to measure mathematical achievement. One test measured mathematical problem solving and critical thinking. The other evaluated computational fluency. The researcher used an instrument that measured attitude toward mathematics in a three-dimensional way: enjoyment of, difficulty of, and perceived importance of mathematics. Several key findings were revealed. For instance, the importance of mathematics to students was seen to be independent of the other attitudinal variables. Ma (1997) drew two conclusions: efforts to make students understand the importance of mathematics may not necessarily increase other positive attitudinal traits and frustrations or enjoyment in learning or using mathematics are unlikely to affect students' views on the importance of mathematics. Bi-directional relationships were observed between each of the three attitudinal variables and achievement in mathematics. The greater effect was from the attitudinal measures toward achievement; but achievement did exert a lesser feedback effect on the attitudinal variables (Ma, 1997). Difficulty was also shown to be significantly related enjoyment in the mathematics classroom, although it did not have a direct effect on achievement (only indirectly through enjoyment). The researcher recommends that math content be

presented in an "interesting and attractive way" in order to ensure this relationship does not negatively affect classroom outcomes (Ma, 1997, p. 227). A very important conclusion is that it is student enjoyment in the mathematics classroom, not perceived difficulty, which has a bearing on mathematical achievement.

Schreiber (2002) examined both institutional and student factors and their effects on student mathematical achievement. The author used hierarchical linear modeling for analysis. The sample for this research consisted of 1,839 American high school seniors – a subset cohort of the Trends in International Mathematics and Science Study. These were students who had studied advanced high school mathematics but had not studied physics. Of interest here are some of the factors the author used to help predict mathematical outcomes. Namely, student level factors such as general attitude toward mathematics, natural talent belief, and hard work belief were used in the model. The author found that all three of these factors were statistically significant predictors of mathematical achievement. The instrument that measured students' attitudes towards mathematics was negatively worded, so the interpretation was that as students attitudes towards mathematics grew more negative, achievement in mathematics was likewise lowered. Schreiber (2002) also found that as students' belief that their success was due to natural talent increased so did mathematical achievement. Another closely related predictor was students' belief that hard work leads to success. The author found that as students' belief that hard work is the key to success decreased, so did mathematical achievement. These latter two results were surprising and the author notes that that his results are not in line with past research (Schommer, 1990). Furthermore, the author speculates that the latter two abnormal results may be the product of the cohort's

demographics. That is, the cohort was comprised of high-achieving mathematics students, many of whom have done exceedingly well in their studies and therefore tend to attribute much of their success to natural talent.

Summary

Mathematics education in the United States is always in flux. Whether it was post-Sputnik era of "New Math" or the "back to basics" movement of the 1970s, one group is always trying to improve mathematics education while another group attempts to cling to the past. After several negative education reports in the 1980s and the publication of *Curriculum and Evaluation Standards for School Mathematics* (NCTM, 1989), problem-based mathematics reforms were called for and implemented in the 1990s and 2000s. This is evidenced by curricula such as the Connected Mathematics Project and Core-Plus mathematics. Curricula like these and others have been demonstrated to be effective in the mathematics classroom and positively affect students' attitudes towards mathematics. Similar research effort has been spent over the past two decades examining the effect of students' attitudes towards mathematics on students' achievement toward mathematics. Most research indicates that positive student attitudes toward mathematics on average result in positive academic outcomes in mathematics. Some research also points to a reciprocal relationship between mathematical achievement and aspects students' attitudes towards mathematics.

CHAPTER III

METHODOLOGY

The purpose of this study is the exploration of the relationship between students' knowledge of basic applied mathematics and students' attitudes towards mathematics. Furthermore, a model will be developed using multiple regression techniques in an attempt to quantify the relationship among students' attitudes towards mathematics and student achievement in mathematics.

Data Collection

Survey methodology was used to gather students' information in this study. Included in the questionnaire distributed to students was an attitudinal measure, a measure of students' knowledge of basic applied mathematics, as well as other items to gather demographic information such as gender, age, and college major. The following procedure was implemented during the data collection process:

1. Permission was sought and gained from the Human Subjects Review Committee of the University of Southern Mississippi Institutional Review Board before any data was collected.

2. Written permission to collect data was sought and gained from the chair of the mathematics department at Mississippi College and the Human Subjects Review Committee of the Mississippi College Institutional Review Board.

3. Permission to recruit students during class time was sought and gained from individual instructors in the mathematics department at Mississippi College.

4. The researcher attended various class meetings and presented the oral recruitment speech to students.

5. Students made appointments with the researcher to complete the questionnaires and mathematics quiz.

6. Questionnaires were distributed and collected in the Fall 2014 semester over a two-week period.

7. Final course grades were collected from instructors at the end of the Fall 2014 semester

8. Data was analyzed and prepared for presentation following data collection.

Participants

Participation in this study was open to any student currently enrolled at Mississippi College. Specifically, the researcher targeted for recruitment students who were enrolled at Mississippi College and were taking a mathematics course in the Fall 2014 semester. Undergraduate, non-mathematics majors were the primary target demographic, but participation was open to all undergraduate students. The researcher arranged times with instructors to give a brief description of the study and recruit participants at the end of class periods. Students were then given the opportunity to sign up for a specific date and time to participate in the research study. The researcher also scheduled large blocks of time over several days for students to come and to participate in the research study without an appointment. The researcher originally aimed to recruit at least 125 participants with a sample that is representative of a typical undergraduate mathematics class at Mississippi College. After data collection was complete, a total of 205 students had participated fully. All of the participants were undergraduate students. Nearly all of the participants were non-mathematics majors. Six of the students were not

enrolled in any mathematics course. Those six participants heard of the research through word of mouth and decided to participate.

<div align="center">Instrumentation</div>

The attitudinal scale used in this study is the Attitudes Toward Mathematics Inventory (ATMI) which was developed by Tapia and Marsh (2002). The instrument consists of 40 five-point Likert-type items with responses ranging from Strongly Disagree (1) to Strongly Agree (5). The inventory consists of four sub-scales: self-confidence, value, motivation, and enjoyment. Some items gauge positive attitudes using statements such as "Mathematics does not scare me at all" whereas other items gauge negative attitudes using items like "Mathematics is dull and boring." Eleven of the 40 items are worded in the negative and the remaining 29 items are formulated in a positive manner. In addition, the questionnaire also contained items which sought to gather certain demographic information of students. Specifically, the researcher collected additional data regarding each respondent's age, sex, college major, and the number of times each student had taken college algebra.

The ATMI was originally developed by Tapia (1996) to measure attitudes toward mathematics using a sample of high school students. Tapia and Marsh (2002) later explored how the scale might be used with a sample of college students. The authors tested the instrument using a sample consisting of 134 college students at a Southeastern, public university. The authors used confirmatory factor analysis to test the model. The authors tested reliability of each sub-scale. Cronbach's alpha coefficient was found to be .96 for self-confidence, .88 for enjoyment, .87 for motivation, and .93 for value (Tapia & Marsh, 2002). The model as a whole was found to have a root mean square error of

approximation value of 0.056, a goodness of fit index of 0.99, and an adjusted goodness of fit index of 0.94. These values indicate that the model in its entirety was indeed reliable for the 134 college students sampled. The ATMI was also validated by a team of researchers in Australia using a sample of 699 middle school students (Majeed, Darmawan, & Lynch, 2013).

An instrument was also used to measure students' ability to solve basic applied mathematics problems – the Basic Applied Mathematics Scale (BAMS). This scale was developed by the researcher in the Fall of 2012 and the Spring of 2013. The scale consists of 17 items, each of which illustrates a common application of mathematics in the real world. The instrument contains exercises pertaining to concepts such as the distance formula, determining store sale prices, or break-even analysis. Each question can be solved using arithmetic and algebra covered in junior high and high school mathematics courses. See Appendix B for details. Content validity of the scale was established via meetings with local mathematics instructors and professors in which applied arithmetic and algebra were thoroughly discussed in order to compose a scale which covered the most common real-world applications of algebra and arithmetic. The instrument was piloted in the Spring of 2013 to test for internal consistency. With a pilot sample of 45 students representative of future total sample, the BAMS was found to have a Cronbach's alpha of 0.778. This indicates that the BAMS had an acceptable level of internal consistency – meaning that all of the individual items on the BAMS theoretically measures the construct – students' applied mathematics skill level.

Procedures

After gaining IRB approval during the summer of 2014, data were collected in the Fall semester of 2014. Both the attitudinal scale and the BAMS were administered in pencil and paper form. Data collection took place in the Math, Chemistry, and Computer Science Building (MCC) on the campus of Mississippi College – room MCC 117A. Participants were given the opportunity to sign up for a specific time slot to participate in the study or come at their convenience. Data collection took place over a two-week period beginning September 8, 2014. All students were given informed consent before participating in the study. Students were also screened in order to ensure that each participant was of at least 18 years of age. The researcher also verbally described the study to all participants and answered any student questions regarding the research.

In addition to collecting data via the two questionnaires, the researcher gained each participant's written permission to use the final grade of the mathematics class in which each participant is currently enrolled. After final grades were posted, the researcher contacted mathematics instructors and gained this information regarding each participant. Twenty-four of the original participants had dropped their respective mathematics course and were therefore not included in any analysis that required the use of participants' final course grades.

Data Analysis

Correlation techniques, specifically multiple regression analysis, was the predominate method used during data analysis. Descriptive statistics were also used to gather an overall summary of the sample. Descriptive statistics and frequencies such as age, sex, and college major were compiled. Multiple regression was then used to explore

the relationship between students' basic applied mathematics skills and students' attitudes towards mathematics. Furthermore, the researcher used final course grades to examine the effect of attitude on student mathematical achievement in general. It has been demonstrated that past research supports the proposition that students' attitudes towards mathematics affect achievement in mathematics (Ma, 1997). The researcher intends to clarify the relationship between basic applied mathematics skill and student attitudes towards mathematics in this study. Furthermore, it stands to reason that basic applied mathematics skill will directly influence overall mathematical achievement since solving applied math problems is typically a subset of measuring mathematical achievement in its entirety.

<div align="center">Summary</div>

The methodology for this study consists of an attitudinal questionnaire, a questionnaire which measures students' basic applied mathematics skills, and students' final semester grades. Using these data, the researcher explored the relationship between students' attitudes towards mathematics and students' basic applied mathematics skills – therefore answering the research questions posed in Chapter I.

CHAPTER IV

ANALYSIS OF THE DATA

This research aimed to examine the relationship between students' ability to use mathematics in an applied setting with students' attitudes towards mathematics. As a result of these analyses, other educators and education researchers may be able to better understand methods to foster positive student attitudes towards mathematics and ultimately promote increased achievement in the mathematics classroom.

The ATMI was the tool used to measure students' attitudes towards mathematics in this research. The scale was developed by Tapia and Marsh in 2002. It was originally developed by Tapia and Marsh using a sample of high school students but was later validated using a sample of college students. The scale consists of 40 Likert-style items – each with possible responses: strongly disagree, disagree, neutral, agree, or strongly agree. Some of the items are stated positively and some are stated negatively. Each of the responses is given a value one through five for the positively stated items and a five through one for the negatively stated items. The instrument is divided into four subscales: value, enjoyment, self-confidence, and motivation. The value and enjoyment subscales consist of 10 items each. All of the items measuring value are positively stated. One of the items measuring enjoyment is negatively stated. The self-confidence subscale consists of 15 items, nine of which are negatively stated. The motivation subscale consists of five items. One of the motivation subscale items is stated negatively.

The BAMS was the tool used to measure students' basic applied mathematics skill. The BAMS was developed and pilot tested during the 2012-2013 school year. It

consists of 17 exercises that mimic real world situations where mathematics can be used. The score was recorded as a percentage of points out of 100. No partial credit was given.

A total of 214 students participated in the research. Of those participants, several had to cease participation prematurely to make scheduled appointments such as sporting practice or class. Therefore 205 (N=205) records were able to be used in the analyses.

<div align="center">Descriptive Statistics</div>

Sample

Demographic data were collected from all participants. These data include each participant's age, sex, and college major, and whether or not the participant had taken college algebra in the past. Of the 205 participants, 53.7% were female while 46.3% were male. In regard to age, 35.1% of the sample were 18 years old, 21.5% were 19 years old, 18% were 20 years old, 11.2% were 21 years old, 6.3% were 22 years old, and the remaining 7.9% ranged in age from 23 to 39.

Each participant also indicated their elected college major. These data were very diverse given the number of possible college majors. The most common major for students participating in this research was biology (21.5% of participants). Business majors followed with 11.2% of the sample. The majors of computer science, chemistry, nursing, kinesiology each represented between five and 10 percent of the sample. The remaining college majors each had less than 5 percent representation in the study sample. See Table 1 for a summary of the demographic information of the sample.

Data were collected regarding the mathematics course in which each participant was enrolled in during the Fall 2014 semester. Non-mathematics-majors enrolled in non-mathematics-major courses were the primary target population. This certainly was the

case with the research sample. Calculus I, a very common course for non-majors and common pre-requisite for other courses, was the course with the highest representation among the sample (31.7%). Finite Mathematics was the current course of 17.2% of the sample whereas College Algebra was the current course of 13.2% of the sample. Students enrolled in Elementary Statistics comprised 10.2% of the sample. Six participants were not enrolled in any mathematics course. The remaining 24.4% of the research sample was enrolled in courses such as Trigonometry, Contemporary Mathematics, Developmental Mathematics, Calculus III, Mathematics for Teachers, Probability and Statistics, or Foundations of Mathematics.

Table 1

Sample Demographic Information (Age, Sex, Popular Majors, and Current Math Course)

		Frequency	*Percent*
Age			
	18	72	35.1
	19	44	21.5
	20	37	18.0
	21	23	11.2
	22	13	6.3
	23 and over	16	7.9
Sex			
	Male	95	
	Female	110	53.7
Popular Majors			
	Biology	44	21.5
	Business	23	11.2
	Chemistry	17	8.3
	Nursing	16	7.8
	Computer Science	13	6.3
Current Course			
	Calculus I	65	31.7
	College Algebra	27	13.2
	Finite Mathematics	36	17.6
	Elementary Stats	21	10.2
	Various Other courses	50	24.4
	No Math Course	6	2.9

Data were also collected regarding the past coursework taken by each participant while in college. Since college algebra is the sole college mathematics course many students must take and many students often struggle with it, data were gathered pertaining to the number of times each participant had attempted to take the course. It was found that 50.2% of the sample was currently enrolled in a mathematics course but had never enrolled in college algebra before. The remaining 49.8% of the sample had either taken college algebra and then moved on to another mathematics course required for their major or had repeatedly taken college algebra. In fact, 4.5% of the sample had taken college algebra at least two times.

Descriptive Analysis of the Data

Data were collected in the Fall semester of 2014. The two main components of this research study were an attitudinal measure and an applied mathematics quiz. The Attitudes Towards Mathematics Inventory (ATMI) was used to measure students' attitudes towards mathematics while the Basic Applied Mathematics Scale (BAMS) was used to measure students' basic applied mathematics skill. The BAMS consists of 17 applied mathematics exercises. A student's score is calculated simply by taking the ratio of total points earned to total points possible. There was no partial credit given. Therefore, the possible scores for the BAMS range from zero to 100. The ATMI consists of 40 5-point Likert items. This yields a minimum possible total score of 40 and a maximum total score of 200. A score of 40 would indicate an extremely unfavorable outlook towards mathematics while a score of 200 would indicate an extremely positive outlook towards mathematics. Furthermore, the ATMI consists of four subscales: value, enjoyment, self-confidence, and motivation. The value subscale is comprised of 10 items,

yielding a possible minimum score of 10 and a possible maximum score of 50. The enjoyment subscale is comprised of 10 items, yielding a possible minimum score of 10 and a possible maximum score of 50. The self-confidence subscale consists of 15 items, yielding a possible minimum score of 15 and a possible maximum score of 75. The final subscale, motivation, consists of five items, yielding a possible minimum score of five and a possible maximum score of 25. See Appendix L for a summary graph of the ATMI data.

The mean for the value subscale was 40.53. The value subscale had the mean most close to its maximum (50). On average, the data indicate that most participants placed a relatively high value on learning and using mathematics. Participants often indicated a high value of mathematics while at the same time expressing low self-confidence towards or enjoyment of mathematics. The value subscale was the only subscale not to have a reported minimum value at the possible lowest value (or extremely close). The minimum response on the value subscale was 20 whereas the lowest possible score for the value subscale was 10. All other subscales had reported values at their minimum possible value or very close to the minimum possible value.

The enjoyment subscale mean was 33.92. An average neutral Likert-type response would be 30 for this subscale. Therefore a mean of 33.92 indicates that participants on average had a slightly positive response to the enjoyment of mathematics items on the questionnaire – just 3.92 points above a mean neutral response. Students' enjoyment, although slightly positive, was much weaker than students' value of mathematics.

The self-confidence subscale had a mean of 52. With a maximum of 75 and a minimum of 15, this mean fell at about 69.3% of the highest possible average score. The

data indicate that more students than not have a fairly high level of self-confidence when doing mathematics. Individual questionnaires and quizzes reveal that a high level of self-confidence, however, does not necessarily translate into higher scores on actual assignments.

The motivation subscale had a mean of 14.4 with a minimum of 5 and a maximum of 25. The sample mean was therefore about two points above an average neutral response. The data indicate a marginally positive motivation statistic for the sample.

In total, the mean ATMI score for the sample was 140.7. The lowest reported score on the ATMI was 61 while the highest reported score was 197. Consistent neutral responses across each of the 40 items would yield a score of 120. The sample mean was therefore 20.7 points above an average neutral attitude towards mathematics. The data indicate that the sample on average had a favorable outlook toward learning and using mathematics. See Table 2 for a summary of descriptive statistics pertaining to the Attitudes Toward Mathematics Inventory.

Table 2

Descriptive Statistics of the ATMI

	Minimum	Maximum	Mean	SD
Value Subscale	20	50	40.53	5.83
Enjoyment Subscale	11	50	33.92	9.11
Self-confidence Subscale	15	75	52.01	13.71
Motivation Subscale	5	25	14.40	4.36
Total ATMI Score	61	197	140.72	29.56

The BAMS had a mean score of 73.5. The scores ranged from 17.6 to 100. The lowest score of 17.6 translated into achieving three correct answers out of a possible 17.

The maximum score of 100 was achieved by a perfect score – solving 17 out of 17 exercises correctly. The median score of the sample was 76.5. The first quartile was 61.75 and the third quartile was 88.2.

Final mathematics course grades for each participant were also collected at the end of the semester. Each participant gave the researcher permission to contact their mathematics instructor at the end of the semester in order to gather their final course grade. Grades were reported in numerical form. Of the original 205 participants, 24 students dropped the mathematics course they were enrolled in during the Fall 2014 semester. Six of the participants were not enrolled in any mathematics course during the semester. Those six students simply responded to flyers and decided to participate in the research. For those participants who were enrolled in and completed a mathematics course in the Fall 2014 semester, there was a mean final grade of 88.3. The median final mathematics course grade was an 84.8. The first quartile was equal to 77 while the third quartile was equal to 91.1. See Table 3 for summary statistics of the final course grades and BAMS scores.

Table 3

Descriptive Statistics of BAMS and Final Course Grade

	N	Minimum	Maximum	Mean	SD
BAMS Score	205	17.6	100.0	73.52	18.00
Final Grade	175	18.0	102.7	83.02	12.48

Inferential Statistics

The purpose of this research was to examine the relationship between students' applied mathematics skill and students' attitudes towards mathematics. Two statistical analyses were conducted. For both analyses, the predictor variables consisted of the four

subscales that comprised the Attitudes Toward Mathematics Inventory: value, enjoyment, self-confidence, and motivation. The dependent variable for the first analysis was the BAMS – the instrument that measures how well students are able to use basic mathematics in everyday situations. For the second analysis, the BAMS score was replaced by the actual final mathematics course grade for each participant. Multiple regression was the statistical technique used for both analyses.

Assumptions of Multiple Regression

There are several main assumptions associated with multiple regression: independent observations, homoscedasticity, normal distribution of the residuals, and linearity. The independence of observations can be assumed because of the research methods by which data was collected. The remaining three assumptions were tested statistically, graphically, or in both manners. Both dependent variables (BAMS score and final course grade) were graphically tested for homoscedasticity. Both scatter plots demonstrated that the error variance was indeed consistent across varying values of the predictor variables. No funneling was observed. Both sets of residuals were also check for normality. The first residuals (with dependent variable BAMS) were normally distributed with skewness and kurtosis well within the acceptable ranges. The second set of residuals (with dependent variable final course grade) had a kurtosis of 4.58 – outside the range of acceptability. Scatterplots were used to check for linearity. In both separate regressions, all predictors were graphically observed to have a linear relationship with their respective dependent variables. Both sets of tolerance values were examined to screen for issues with multicollinearity – no problems were detected (all tolerance values were greater than 0.1). Studentized residuals, standardized DFFITS, and leverage values

were calculated and examined. Several records were flagged as outliers according to these diagnostic tests. When the data were double-checked, it was confirmed that all records were entered correctly. It was simply the case that these records represented true outliers – participants who scored very low or high on certain instruments. Those identified records were removed and both regression analyses were re-run. In both cases, the regression outcomes were the same. Therefore the outlier records were placed back into the data set. With the one exception noted, all other assumptions of multiple regression were satisfied.

Results of Inferential Statistics

The goal of the first research question was to establish the nature of the relationship between students' applied mathematics skill and students' attitudes towards mathematics. In the context of multiple regression, this research question was aiming to determine if any of the predictor variables (ATMI subscales) are useful in explaining the behavior of the dependent variable: BAMS score.

Hypothesis 1: At least one of the predictors (value, enjoyment, self-confidence, and motivation) is statistically significant in explaining variability in the BAMS and has a standardized regression coefficient not equal to zero.

The results of this analysis found that the overall model was indeed significant, $F(4,200) = 21.13$, $p < .001$. Hypothesis 1 was supported. The model produced an R^2 value of 0.297, implying that 29.7% of the variance in the BAMS can be explained by the set of predictor variables. Only two of the four predictor variables had a statistically significant relationship with the dependent variable. Self-confidence was shown to be statistically significant, $t(200) = 4.18$, $p < 0.001$. Motivation was also shown to be a statistically

significant predictor, $t(200) = 2.22$, $p = .028$. The self-confidence predictor had a Beta

value of 0.45, implying that for every one standard deviation increase on the self-

confidence subscale, a 0.45 standard deviation increase would be observed on the BAMS,

controlling for all other variables. Similarly, the motivation independent variable

produced a Beta value of 0.25, which indicated that for every one standard deviation

increase in motivation, a 0.25 standard deviation increase would be observed on the

BAMS, controlling for all other variables.

   The second goal of this research was to see whether or not students' attitudes

towards mathematics had any bearing on students' final semester mathematics course

grade. Multiple regression was also used for this analysis.

    Hypothesis 2: At least one of the predictors (value, enjoyment, self-confidence,

    and motivation) is statistically significant in explaining variability in students'

    final semester mathematics course grade and has a standardized regression

    coefficient not equal to zero.

   The second model failed to adequately explain variability in the dependent

variable, final course grade, $F(4,170) = 2.06$, $p = .089$. The hypothesis that all of the

predictors' standardized regression coefficients are not equal to zero was therefore not

supported. It is the case therefore, with the current sample, that none of the attitudinal

independent variables significantly predict mathematical achievement as represented by

students' final mathematics course grade.

   Finally, the relationship between the BAMS and students' final course grades was

examined. Linear regression was used with the BAMS as a predictor and final course

grade as the dependent variable. It was found using linear regression that the relationship

between these two variables was indeed statistically significant, F (1,173) = 10.98, p=.001. This model had an R^2 value equal to .06, which indicated that 6% of the variability in final course grades was explained by the BAMS. The model produced a Beta value of 0.244, which indicated that for every one standard deviation increase on the BAMS, a 0.244 standard deviation increase should be observed in final course grade. Furthermore, the relationship between the two measures of student achievement were found to be statistically correlated (r=0.244).

Summary

Two potential statistical models were tested. The first model examined the statistical relationship between students' attitudes toward mathematics and student basic applied mathematics skill. This model was found to be statistically significant. The second model looked at the relationship between students' attitudes toward mathematics and students' final mathematics course grade. This relationship was not shown to be statistically significant for the observed sample. Lastly, the analyses showed that a statistically significant relationship does indeed exist between students' basic applied mathematics skill and students' final mathematics course grade.

CHAPTER V

CONCLUSIONS AND DISCUSSION

The purpose of this research was to determine if a relationship exists between students' attitudes toward mathematics and students' ability to use basic mathematics in their everyday lives. Furthermore, the research aimed to see if either of these constructs had any relationship to students' achievement in mathematics courses. This chapter will provide a brief summary of the research procedures and results, a discussion of the results, limitations of the study, and recommendations for further research in the subject area.

Summary of Procedures and Results

Institutional Review Boards' approvals were sought and gained during the summer of 2014. Data were collected during the Fall 2014 semester at Mississippi College – a small, religiously-oriented, private college in Clinton, Mississippi. The researcher contacted instructors in the mathematics department before the fall semester began and made arrangements to recruit students at the end of certain class periods during the first few weeks of the semester. Students were allowed to make appointments to meet with the researcher. Data collection took place over the second and third week of September, 2014. Participants spent approximately 30 minutes completing an attitudinal questionnaire and basic applied mathematics quiz. The research sample consisted of 205 students, the overwhelming majority of whom were non-mathematics majors enrolled in non-mathematics courses. The final mathematics course grade was then collected for each participant after the completion of the Fall 2014 semester. Each participant signed a form allowing the researcher to contact their mathematics instructor after the end of the

semester in order to gather their grade. Numerical grades were collected from the mathematics instructors for all but 24 participants. Those 24 students had dropped their respective mathematics course.

Descriptive analyses of the sample revealed that most participants placed a relatively high value on learning and using mathematics. The mean sample score for the value subscale was 40.53 out of a maximum score of 50. The median was 41. This result is interesting because the negative skew indicates that most participants placed a high value on learning and using mathematics regardless of how they responded to other subscale items or how well they did on the basic applied mathematics quiz.

It was also observed that most students expressed high levels of self-confidence in their mathematical abilities. The mean value for the self-confidence scale was 52, while the median was 55. The reported self-confidence levels were much higher than a neutral response of 30 points. Again, these high levels of self-confidence did not necessarily translate into higher scores on the BAMS or final course grade for all students.

The enjoyment subscale had the lowest reported attitudinal score. The mean reported score was 33.92 while the median was 35. This resulted in a slight negative skew of -0.38 for the subscale. A neutral response would have been a 30. Therefore the sample as a whole expressed enjoyment with math levels just slightly above neutral.

The final subscale was motivation and reported values resulted in a mean of 14.4 and a median of 14. A complete neutral response would have been 12.5.Therefore motivation levels for the sample were about two points in the positive direction.

The first hypothesis to be tested dealt with the relationship between students' attitudes toward mathematics and students' ability to use basic applied mathematics in

their everyday lives. As a measure of the latter, the Basic Applied Mathematics Scale was used. The Attitudes Toward Mathematics Inventory was used as a measure of students' attitudes and opinions. It was found using multiple regression analysis that there was indeed a statistically significant relationship between the two constructs. Specifically, two subscales of the ATMI were revealed to be significant predictors of students' basic applied mathematics skill, accounting for 29.7% of the variance in BAMS scores.

The second hypothesis tested dealt with students' attitudes toward mathematics and whether or not this affected students' final mathematics course grade. Multiple regression analysis did not reveal a statistically significant relationship between these two constructs with the given research sample.

<div align="center">Discussion of Results</div>

Much past research has been conducted to examine the link between students' attitudes and opinions toward mathematics and students' achievement in mathematics. Conflicting evidence has been demonstrated. Some researchers have found a statistically significant link between students' attitudes towards mathematics and students' achievement in mathematics (Ma, 1997; Mriano, 2005; Singh et al., 2002). Others, however, have found that either the relationship is non-significant or the relationship is so weak as to have little to no practical significance (Ma & Kishor, 1997). Ma and Kishor (1997) conducted a meta-analysis of 113 primary research studies that examined this exact relationship and found that although a statistically significant relationship did indeed exist, the mean effect size was .012.

The purpose of this research was more specific than simply looking at students' attitudes toward mathematics and students' achievement in mathematics. The aim of this

study was to examine students' attitudes towards mathematics as it relates to their level of competence to use mathematics in their everyday lives. Mathematical achievement in general was a secondary relationship to be examined. As outlined in the results, the researcher found that there did indeed exist a statistically significant relationship between students' ability to use mathematics in their everyday lives (approximated by the BAMS) and students' attitudes toward mathematics (approximated by the ATMI). The result is, however, tempered by the fact that not all of the subscales of the ATMI were significant predictors.

The first subscale, students' professed value of mathematics was found not to be a significant predictor of students' ability to perform daily, applied mathematics. This result was completely expected, considering the descriptive analysis of the same subscale. Descriptive analysis of the value subscale found that the average reported value for the subscale was 40.53. This indicated that most students placed a high value on learning and using mathematics. The other side of this result, however, is that this variable was non-significant in predicting BAMS scores. This is because the overwhelming majority of participants rated their value of mathematics very high, regardless of their achievement on the BAMS.

This result appears to indicate that, at least for the research sample, students, on average, have bought in to the importance of learning and using mathematics. This result was surprising to the researcher. Anecdotal evidence from teachers and parents often point to more prevalent negative student views towards the value of learning and using mathematics. Teachers and parents often hear students say things such as "I hate math." or "Math is boring." This result seems to indicate that although those opinions are

commonly expressed; most students actually place a high value on learning and using mathematics. A similar conclusion was reported by Ma (1997) where it was found that students' perceived importance of mathematics was found to be independent of other attitudinal measures and not a statistically significant predictor of achievement in mathematics.

The second subscale on the ATMI was enjoyment. This subscale also was found to be a non-significant predictor of student achievement on the BAMS. The median for the enjoyment subscale was 35 while the mean reported score was 33.92. There was a slight negative skew, indicating that slightly more students had positive responses to the enjoyment items than had a negative response. The fact that enjoyment of mathematics did not have a significant relationship to achievement on the BAMS was surprising to the researcher. One would surmise that students who enjoy mathematics would also tend to do well on mathematical assignments. Furthermore, it is logical that the relationship might be reciprocated. For instance, it may be the case that doing well in mathematics contributes to a higher level of enjoyment in mathematics. From the evidence presented here, it is not necessarily the case with the current sample.

One possible explanation for this unexpected discrepancy could depend on what students view as mathematics. That is, students may be referring here to the fact that they enjoy solving equations, derivatives, or integrals (typically easy mathematical exercises without much context). The mathematics on the BAMS, however, was fully applied, real-world mathematics. Typically referred to as "world problems," these are oftentimes the type of mathematics students struggle with the most since students must devise their own formulas from the text. Consequently, the disconnect here *could* be explained by the fact

that when students say they enjoy mathematics, they are really saying that they enjoy another area of mathematics where they perform, on average, much better. A similar research study could use an attitudinal scale in conjunction with *both* an applied measure of mathematical achievement and a non-applied (computational fluency oriented) measure of mathematical achievement. Perhaps a stronger relationship between students' enjoyment of mathematics and achievement would be present if the achievement was in the context of non-applied mathematics.

The third subscale to be evaluated was self-confidence. This subscale did prove to be a statistically significant predictor of students' basic applied mathematics skill. This result is in line with past research dealing with self-confidence and self-efficacy and mathematical achievement in general. Liu and Koirala (2009) found, using regression analysis, that mathematical achievement could be statistically predicted by students' levels of self-confidence. Similar conclusions were drawn by Aryana (2010) and Hamid, Sharill, Matzin, Mahalle, and Mundia (2013). These results make perfect sense. It is intuitive that one's self-confidence would lead to higher performance in a given area. However, others have argued that this relationship may not be so clear-cut. Baumeister, Campbell, Kruger, and Kohs (2003) theorized that the relationship between these two constructs is oftentimes proposed in the wrong direction. For instance, the authors assert that self-confidence (or the lack thereof) stems from success (or failure) in a particular subject area. So it is perhaps not the self-confidence that leads to success, according to the authors of the research. Rather, it is the success that leads to self-confidence. This was the idea that the researcher was considering here in the present study. Does a student's ability to use mathematics effectively affect a student's outlook towards mathematics?

Multiple regression analysis only allowed for the directionality to be formally tested in one direction. That is, the statistical tests only pertained to self-confidence affecting achievement – not vice versa. However, the relationship may indeed be bi-directional in reality, especially considering the fact that the ATMI in its entirety was shown to have a statistically significant, positive correlation with the BAMS. More research is needed in this area – both specific to mathematics and self-confidence theory in general.

The fourth subscale of the ATMI was motivation. This construct was shown to have a positive relationship with students' performance on the Basic Applied Mathematics Scale. This result confirms and expands research regarding student motivation and student achievement in mathematics. Singh et al. (2002) found that two different dimensions of motivation were significantly related to achievement in mathematics. Reynolds and Walberg (1992) devised a similar structural model that demonstrated motivation having both direct and mediating effects on mathematical achievement and students' attitudes towards mathematics in general. These data confirm that motivation is positively related to mathematical outcomes, but also that mathematical outcomes are positively related to student motivation.

As with the self-confidence subscale, the bi-directional relationship between the BAMS and motivation is of interest. The researcher suspects that exists a feedback effect between the two variables. That is, it may be the case that motivation affects achievement but also that achievement affects motivation. As students receive positive feedback (in the form of good grades) in the mathematics classroom, it may be the case that they experience higher levels of motivation. The research design did not allow for this relationship to be tested explicitly. However, since the ATMI and BAMS were overall

statistically significantly correlated, one could presume that the relationship between motivation and achievement on the BAMS was indeed bi-directional.

One disappointing aspect of this research was the fact that students' attitudes towards mathematics in general was not found to have a statistically significant relationship with students' final mathematics course grade. In their meta-analysis, Ma and Kishor (1997) found that there was an overall net positive relationship between students' attitudes toward mathematics and students' achievement in mathematics. That result was not replicated in this sample. The researcher expects the reason is because most students reported quite positive attitudes towards mathematics – even when their BAMS score and final course grade were quite low. On the other hand, it is certainly a desired result, in the sense that positive attitudes toward mathematics are a good thing – regardless of how students actually perform academically. As previously speculated, the disconnect may be related the fact that most of what students consider "doing mathematics" entails solving rote, non-contextual exercises – not applied "word problems."

Worthy of note, however, is the fact that a positive, significant relationship was demonstrated between students' final course grade and students' scores on the BAMS using both linear regression and examining Pearson's *r*. Although a significant statistical link was not demonstrated between students' attitudes towards mathematics and students' final mathematics course grade, separate significant correlations were demonstrated here between students' attitudes towards mathematics and the BAMS *and* between the BAMS and students' final course grade. Further research and a larger research sample may be necessary to tease out the relationship amongst these three constructs.

The main model in its entirety was demonstrated that, for the sample at hand, a significant relationship existed between students' attitude toward mathematics and students' ability to use basic applied mathematics. This was the overarching aim of the study. Many researchers have examined the effects of *teaching* from an applied standpoint and how student achievement is either increased or decreased (Boaler, 1998; Riordan & Noyce, 2001; Ziegler & Yan, 2001). The goal of this research was more nuanced. The researcher in this study was not interested in instructional methods. The researcher was looking at students *after* they learned mathematical concepts in class (regardless of instructional method) to see if once students learned a skill and were able to use it, did this have any relationship with their attitudes towards mathematics. This result is of importance, for it leads to a possible avenue for affecting student achievement in general. Much research has shown that positive attitudes towards mathematics are positively linked to better outcomes in the mathematics classroom (Ma & Kishor, 1997). But again, this research was more specific. The research at hand demonstrated that positive, significant relationship exists between students' ability to use mathematics in the real world and students' attitudes towards mathematics. Therefore, fostering students' attitudes towards mathematics may be achievable through showing students how the mathematics they learn in the classroom is useful to them in their everyday lives in the real world. This may, in turn, result in increased student performance in the mathematics classroom.

<div align="center">Summary</div>

Mathematics is important for everyday life. From evaluating sales at the grocery store to making informed decisions regarding taxes, student loans, or retirement savings,

mathematics is necessary and commanding knowledge of it yields a distinct advantage in life. It is imperative that educators continually strive to improve the outcomes of their students' – the very same citizens who need mathematical skills to adeptly navigate their day-to-day lives. This research has demonstrated a possible way to improve students' outcomes via increased positive attitudes toward mathematics. If educators can effectively show students not only how to use mathematics in the classroom, but how to use that same mathematics to their advantage in their everyday lives, students' attitudes towards mathematics may be increased and consequently achievement toward mathematics may be increased as well.

Limitations

1. This study was conducted at a private, religiously-oriented college in the Southeastern United States. The research sample therefore may not represent the college-age population as a whole in the United States.

2. This research relied on self-selection. That is, students strictly volunteered for the study. Participants could have had many different motivations for participation – anything from altruism to increasing their standing in the eyes of their peers or professors. More importantly, those students who did not participate may on average possess more extreme attitudes towards mathematics – be it negative or positive.

3. This study also relied on self-report. As with any questionnaire, participants could purposefully mislead the researcher or rush through the questionnaire without paying it proper attention. Some students participated in the research between

classes or other appointments, so time was an issue for them when completing the quiz and questionnaire.

4. Due to research design, analyses were only conducted in "one direction." That is, the researcher was able to examine how "a" affects "b," but could not specifically examine the reverse relationship where "b" affects "a." In some cases, this reverse analysis might possibly have yielded interesting results.

<div align="center">Recommendations for Further Research</div>

1. Self-confidence and motivation were the two significant predictors of achievement on the BAMS. These two constructs and their relationship toward achievement in mathematics should be investigated in greater detail. Furthermore, if the results regarding these two constructs are replicated, mathematics instructors should find ways to foster these constructs to in turn bolster the achievement of their students.

2. Research should be conducted with the statistical analyses that allow bi-directional tests between the attitudinal scale and the BAMS. Bi-directional relationships were not allowed in the current study due to its research design. Further research should explicitly look at these reverse relationships.

3. The relationship between students' overall mathematical achievement and students' attitudes toward mathematics should be examined in more detail. On average, the relationship between students' attitudes and students' mathematical achievement is positive, though sometimes small. That was not observed in this sample. Perhaps a larger and more diverse cohort would make a difference.

4. Further research should be conducted that relates students' applied mathematics skill, students' attitudes towards mathematics, and students' overall achievement towards mathematics. This perhaps could be accomplished by using structural equation modeling or other appropriate techniques.

APPENDIX A

ATTITUDES TOWARD MATHEMATICS INVENTORY (ATMI)

<u>Demographic Information</u>

Age:_____   Sex: ____Male
                                       ____Female

Have you taken college algebra before? _____

If so, how many times? _____

Directions: This inventory consists of statements about your attitude toward mathematics. There are no correct or incorrect responses. Read each item carefully. Please think about how you feel about each item. Circle the choice that most closely corresponds to how the statements best describe your feelings.

Complete your responses for all 40 statements.

1. Mathematics is a very worthwhile and necessary subject.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

2. I want to develop my mathematical skills.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

3. Mathematics helps develop the mind and teaches a person to think.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

4. Mathematics is important in everyday life.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

5. Mathematics is one of the most important subjects for people to study.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

6. Math courses would be very helpful no matter what grade level I teach.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

7. I can think of many ways that I use math outside of school.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

8. I think studying advanced mathematics is useful.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

9. I believe studying math helps me with problem solving in other areas.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

10. A strong math background could help me in my professional life.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

11. I get a great deal of satisfaction out of solving a mathematics problem.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

12. I have usually enjoyed studying mathematics in school.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

13. I like to solve new problems in mathematics.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

14. I would prefer to do an assignment in math than to write an essay.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

15. I really like mathematics.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

16. I am happier in a math class than in any other class.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

17. Mathematics is a very interesting subject.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

18. I am comfortable expressing my own ideas on how to look for solutions to a difficult

problem in math.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

19. I am comfortable answering questions in math class.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

20. Mathematics is dull and boring.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

21. Mathematics is one of my most dreaded subjects.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

22. When I hear the word mathematics, I have a feeling of dislike.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

23. My mind goes blank and I am unable to think clearly when working with

mathematics.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

24. Studying mathematics makes me feel nervous.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

25. Mathematics makes me feel uncomfortable.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

26. I am always under a terrible strain in a math class.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

27. It makes me nervous to even think about having to do a mathematics problem.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

28. I am always confused in my mathematics class.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

29. I feel a sense of insecurity when attempting mathematics.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

30. Mathematics does not scare me at all.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

31. I have a lot of self-confidence when it comes to mathematics.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

32. I am able to solve mathematics problems without too much difficulty.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

33. I expect to do fairly well in any math class I take.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

34. I learn mathematics easily.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

35. I believe I am good at solving math problems.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

36. I am confident that I could learn advanced mathematics.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

37. I plan to take as much mathematics as I can during my education.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

38. The challenge of math appeals to me.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

39. I am willing to take more than the required amount of mathematics.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

40. I would like to avoid teaching mathematics.

Strongly Disagree   Disagree   Neutral   Agree   Strongly Agree

Do you have any thoughts or opinions regarding mathematics that were not covered in the questionnaire you just completed? If so, you may discuss those ideas in the space provided below.

APPENDIX B

BASIC APPLIED MATHEMATICS SCALE (BAMS)

1. On a long road trip, you travel 260 miles in 4 hours. If you continue at the same rate, how long will the next 650 miles take?

2. Dave has $1.72 in his pocket and wants to buy a soda which costs $1.59 plus tax. If sales tax is 9%, can he afford the soda?

3. Mary wants to buy a new printer. The model she wants is available on Amazon.com from a dealer in the United Kingdom for £30 plus £5 shipping. A domestic seller has the same model available for $55 with free shipping. Should Mary buy the printer from the seller in the United Kingdom or the United States, assuming that £1 will buy $1.61?

4. A Big Mac contains 550 calories. If you can burn 114 calories per mile running, how many miles must you run to burn off the calories from the Big Mac?

5. Your favorite brand of shampoo is sold in two different sizes. The regular size is 14 oz. and costs $2.29 whereas the large size is 17 oz. and costs $3.38. Which size is the better deal?

6. You need to buy two pairs of socks. Target is running a buy one get one half off sale. At Wal-Mart, the sale is 30% off. The non-sale price is the same at both stores. At which store would they be cheaper?

7. I tuned in midgame to the Yankees-Red Sox game the other day and the announcer said that a total of 25 runs had been scored so far and the Red Sox were down by 9. What was the score?

8. Carla needs to make an A in College Algebra. The only grades in the class are 5 tests, and each test is counted equally. If she has made a 95, 86, 97, and 83 on the first 4 tests, what does Carla need to make on her final test to make a 90 in the course?

9. You are planning to make a big batch of homemade cookies. The recipe calls for 2.5 pounds of chocolate. The grocery store sells chocolate in 10 oz. bags. How many bags do you need to buy to make the cookies? Remember, 16 oz. = 1 lbs.

10. An empty truck and driver weigh a total of 4,327 pounds. The truck needs to be loaded with corn, weighing 31 pounds per bag. The truck must cross over a bridge with a 10,000 pound load limit. How many bags of corn can the truck legally carry?

11. John makes and sells crafts at local craft fairs. John spends $2 for each craft he creates and sells each one for $10. If it costs $104 to rent a booth at a local craft fair, how many crafts must John sell to at least break even?

12. The manager of a restaurant prices a glass of wine as follows: divide the bottle price by 4 then add 75 cents. If you know that a glass of wine costs $11, then how much will a bottle of that wine cost?

13. Josh has $65 and wants to rent a Jet Ski while he is at the beach. It costs $25 base rate plus $10 per hour to rent the jet ski. How long can he rent the Jet Ski?

14. Brittany lives in the US and was talking to her friend Elizabeth in Europe. Elizabeth commented that it was a nice warm day since it was 25 degrees outside. Brittany was confused at first, but then realized that Elizabeth was expressing the temperature in Celsius. Express the temperature in Fahrenheit. Use the formula: $T_C = \frac{5(T_F - 32)}{9}$, where T_C is the temperature in Celsius and T_F is the temperature in Fahrenheit.

15. You own a company and give each of your employees a holiday bonus of $250. You want the bonus to be a full $250 after deducting 15% for federal tax, 10% for state tax, and 7.5% for social security. What must the gross (before tax) amount of the bonus be?

16. Sue lives 2 miles from her school. She typically averages 30 MPH on the way to school. One morning Sue is running late and averages 45 MPH on the way to school. How much faster does Sue arrive at school?

17. A city council has proposed the following two methods for calculating property taxes: Method #1 – $2,200 + 4% of the property's value, or Method #2 – $1,200 + 6% of the property's value. If you own property that is worth $60,000, what method of taxation should you prefer?

APPENDIX C

PERMISSION LETTER TO COLLECT DATA AT MISSISSIPPI COLLEGE

Mississippi College
A CHRISTIAN UNIVERSITY

Department of Mathematics

June 5, 2014

To whom it may concern,

Please note that Taylor Kilman has my permission to collect research data in selected courses taught by the Mathematics Department at Mississippi College during Summer 2014, Fall 2014, and Spring 2015. The particular courses utilized must be additionally approved by me as they are selected. The actual usage of these courses is contingent upon also filling out proper paperwork here and receiving the approval of the Mississippi College IRB.

Please let me know if there are any questions.

Respectfully,

John Travis, Ph.D.
travis@mc.edu
601-925-3817

APPENDIX D

ORAL PRESENTATION SCRIPT FOR RECRUITMENT

Hello, my name is Taylor Kilman. I am a doctoral student at The University of Southern Mississippi. I am currently conducting a research project and would love to tell you about it. This study is designed to gather data regarding students' attitudes towards mathematics. This research has the potential to benefit individual participants since the data collected may influence how and what topics are taught in undergraduate math courses. The results may benefit administrators and math educators by providing a better understanding of how students experience introductory mathematics courses. This research could inform educators and help them provide the best possible classroom experience to college algebra students. Since college algebra is a "gateway" course, improved student engagement may result in many student benefits such as lower drop-out and fail rates.

As a part of the research study, I will be distributing questionnaires. The questionnaires will take approximately 30-45 minutes to complete. There are no known or anticipated risks associated with participating in this study. Any information that is obtained during the study about a particular individual will be kept entirely confidential. Participation is optional. The decision to participate is yours and yours alone. You will not be penalized in any way for not participating. You may discontinue participation at any time during this study. The data gathered from the interviews will be aggregated, analyzed, and described in my dissertation. The final paper may be presented at academic conferences or in peer-reviewed journals. Three years after the data from the interviews are analyzed, the data will be destroyed by shredding or deletion. This research is supervised by Sherry Herron, PhD.

This project has been reviewed by the Institutional Review board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about your rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-0001, (601)-266-6820.

I appreciate your time and attention with this project. Thank you very much. I look forward to working with you soon.

APPENDIX E

PERMISSION FORM TO COLLECT STUDENTS' FINAL COURSE GRADE

I, _____, hereby give my consent to allow Taylor Kilman to contact
                     student's name

_____, the instructor of mathematics course
               instructor's name

_____ in which I am currently enrolled and collect my final grade. I
      course name and meeting time

understand that this will be completed for research purposes and will be completed such

that the confidentiality of each student will be ensured. I also understand that

participation in this aspect or any other aspect of this study is strictly voluntary and I may

withdraw my participation at any time by contacting the researcher.

_____   _____

Signature of the Participant   Date

_____   _____

Signature of the Researcher   Date

APPENDIX F

QUESTIONNAIRE COVER LETTER

Dear Participant,

This document is to inform you of the research I am conducting. The study is designed to gather data regarding students' attitudes towards mathematics. This research has the potential to benefit individual participants since the data collected may influence how and what topics are taught in undergraduate math courses. The results may benefit administrators and math educators by providing a better understanding of how students experience introductory mathematics courses. This research could inform educators and help them provide the best possible classroom experience to college algebra students. Since college algebra is a "gateway" course, improved student engagement may result in many student benefits such as lower drop-out and fail rates.

As a part of the research study, I will be distributing questionnaires. The questionnaires will take approximately 30-45 minutes to complete. There are no known or anticipated risks associated with participating in this study. Any information that is obtained during the study about a particular individual will be kept entirely confidential. Participation is optional. The decision to participate is yours and yours alone. You will not be penalized in any way for not participating. You may discontinue participation at any time during this study. I would also like, with your permission, to collect your midterm grade of the mathematics course in which you are currently enrolled. This will be done with the utmost care and will be completely confidential. The procedure for gathering grades is structured so that I will not even know any students' particular grade – all students will be represented by coded numbers and grade will just match a particular record. The data gathered from the interviews will be aggregated, analyzed, and described in my dissertation. The final paper may be presented at academic conferences or in peer-reviewed journals. Three years after the data from the interviews are analyzed, the data will be destroyed by shredding or deletion. This research is supervised by Sherry Herron, PhD.

This project has been reviewed by the Institutional Review board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about your rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-0001, (601)-266-6820.

If you participate in your scheduled interview, you have given permission for this confidential data to be used in research for the aforementioned purpose.

I appreciate your time and attention with this project.

Sincerely,

Taylor Kilman

APPENDIX G

INFORMED CONSENT

ORI | Office *of* **Research Integrity**

INSTITUTIONAL REVIEW BOARD
SHORT FORM CONSENT

SHORT FORM CONSENT PROCEDURES
This document must be completed and signed by each potential research participant before consent is obtained. • All potential research participants must be presented with the information detailed in the Oral Procedures before being signing the short form consent. • The Project Information section should be completed by the Principal Investigator before submitting this form for IRB approval. • Copies of the signed short form consent should be provided to all participants. Last Edited March 5th, 2014

Today's date:

PROJECT INFORMATION		
Project Title: The Relationship Between Students' Applied Mathematics Skill and Students' Attitudes Towards Mathematics		
Principal Investigator: Taylor Kilman	Phone: (601)941-1866	Email: taylor.kilman@eagles.usm.edu
College: College of Science and Technology	Department: Center for Science and Mathematics Education	

CONSENT TO PARTICIPATE IN RESEARCH

Participant's Name: _____

Consent is hereby given to participate in this research project. All procedures and/or investigations to be followed and their purpose, including any experimental procedures, were explained. Information was given about all benefits, risks, inconveniences, or discomforts that might be expected.

The opportunity to ask questions regarding the research and procedures was given. Participation in the project is completely voluntary, and participants may withdraw at any time without penalty, prejudice, or loss of benefits. All personal information is strictly confidential, and no names will be disclosed. Any new information that develops during the project will be provided if that information may affect the willingness to continue participation in the project.

Questions concerning the research, at any time during or after the project, should be directed to the Principal Investigator using the contact information provided above. This project and this consent form have been reviewed by the Institutional Review Board, which ensures that research projects involving human subjects follow federal regulations. Any questions or concerns about rights as a research participant should be directed to the Chair of the Institutional Review Board, The University of Southern Mississippi, 118 College Drive #5147, Hattiesburg, MS 39406-0001, (601) 266-5997.

_____   _____

        Research Participant   **Person Explaining the Study**

_____   _____

            Date   **Date**

APPENDIX H

THE UNIVERSITY OF SOUTHERN MISSISSIPPI IRB ARRPOVAL FORM

THE UNIVERSITY OF
SOUTHERN MISSISSIPPI.

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

NOTICE OF COMMITTEE ACTION

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

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

PROTOCOL NUMBER: 14060608
PROJECT TITLE: The Relationship between Students' Applied Mathematics Skill and Students' Attitudes towards Mathematics
PROJECT TYPE: New Project
RESEARCHER(S): Taylor Kilman
COLLEGE/DIVISION: College of Science and Technology
DEPARTMENT: Center for Science and Math Education
FUNDING AGENCY/SPONSOR: N/A
IRB COMMITTEE ACTION: Expedited Review Approval
PERIOD OF APPROVAL: 06/16/2014 to 06/15/2015

Lawrence A. Hosman, Ph.D.
Institutional Review Board

APPENDIX I

MISSISSIPPI COLLEGE IRB APPROVAL FORM

MISSISSIPPI COLLEGE
INSTITUTIONAL REVIEW BOARD (IRB)
HUMAN SUBJECTS RESEARCH COMMITTEE

Notice of Review: Projects Using Human Subjects

Project Title: The Relationship between Students' Applied Mathematics Skill and Students' Attitudes towards Mathematics.

Principal Investigator: Kilman, Taylor

Date: June 23, 2014

_XX_ 1. In accordance with the MC POLICY FOR PROTECTION OF HUMAN SUBJECTS, the MC IRB – Human Subjects Research Committee reviewed and APPROVED this project on the above date.

The project is subject to annual continuing review and the conditions listed in the comments sections below.
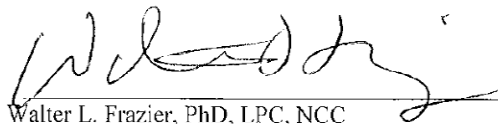
_____ 2. In accordance with the MC POLICY FOR PROTECTION OF HUMAN SUBJECTS, the MC IRB – Human Subjects Research Committee reviewed this project and have determined that the project does not meet IRB standards and is therefore DEFICIENT for the reasons listed below.

_____ 3. This project received full committee review.

_XX_ 4. This project received expedited review.

_____ 5. This project does not require committee approval. This exemption is based on the following part and section of the MC POLICY FOR PROTECTION OF HUMAN SUBJECTS.

DEFICIENCIES AND/OR COMMENTS:

Walter L. Frazier, PhD, LPC, NCC   Date 6/23/2014
Chair, MC Human Subjects Research Committee

Form IRB-3
Rev. 12/09

APPENDIX J

LETTER OF PERMISSION TO UTLIZE THE ATMI

EAGLE APPS

Taylor Kilman <taylor.kilman@eagles.usm.edu>

Attitudes Towards Mathematics Inventory

Tapia, Martha <mtapia@berry.edu>
To: Taylor Kilman <taylor.kilman@eagles.usm.edu>

Dear Taylor,

You have permission to use the Attitudes Toward Mathematics Inventory (ATMI) in your research project. If you have any question, please do not hesitate to ask me.

Please let me know of the findings in your study.

Sincerely,

Martha Tapia

Martha Tapia, Ph.D.

Associate Professor

Department of Mathematics and Computer Science

Berry College

P.O. Box 495014

Mount. Berry, Georgia 30149-5014

APPENDIX K

EMAIL TO INSTRUCTORS ASKING FOR

PERMISSION TO RECRUIT STUDENTS

To Whom It May Concern,

I am collecting data for my dissertation this semester. I was hoping to recruit students from the math classes here on campus. Would you be willing to give me 5 minutes at the end (or start) of any of your classes to give my recruitment speech to your students? It should not take more than 3-5 minutes to explain to them what I am doing and ask them to participate. I am primarily targeting non-majors, but math majors are certainly welcome to participate as well.

Another part of my study will entail the collection of the final course grade for participants who consent for this to be done (this will be done in a confidential AND anonymous manner). Would you be willing to help me out with this also? It will be as easy as me giving you a list of records, you entering a grade, and then tearing off the names of the students so that the grades are not matched with names - just other data.
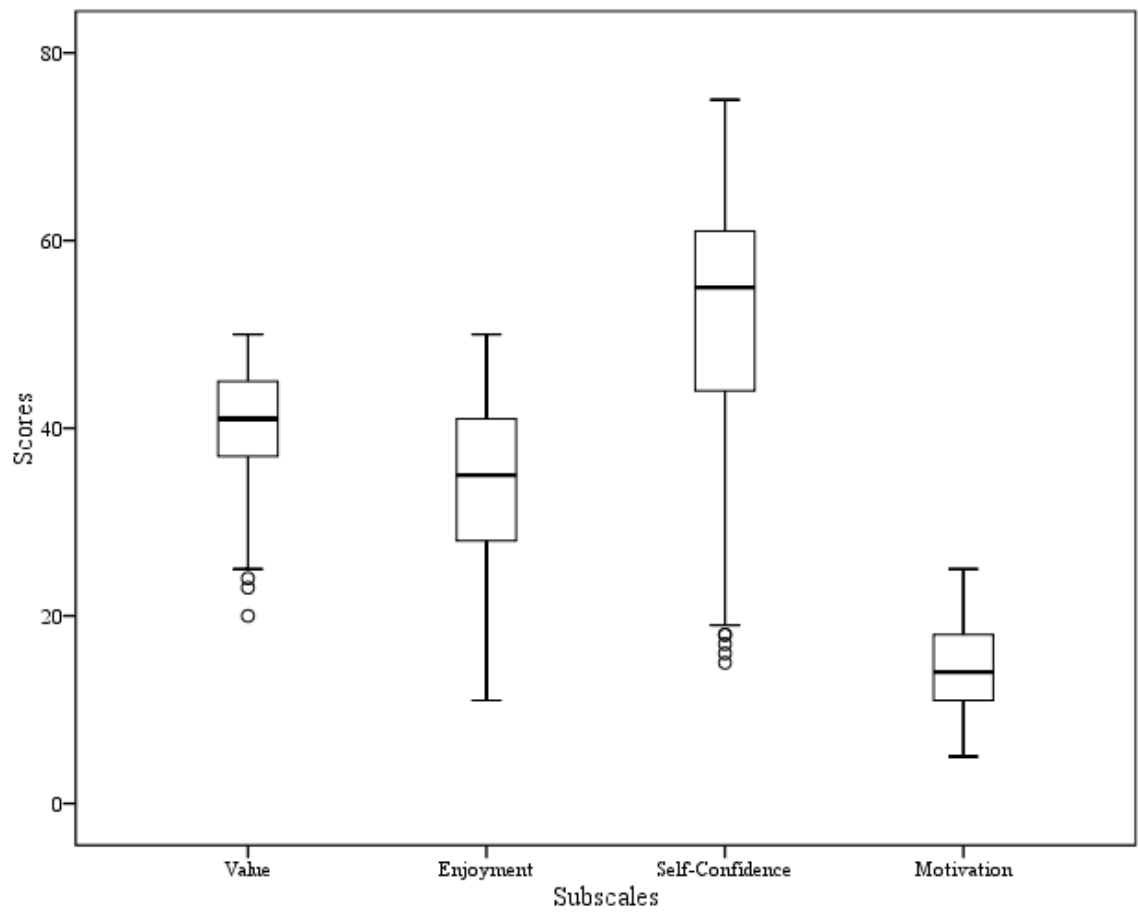
Also, would you be willing to give your students any type of extra credit for participating in my research?

This research has been approved by both the Southern Miss and Mississippi College Institutional Review Boards.

Thank you for your help,

Taylor Kilman

APPENDIX L

BOXPLOT OF ATMI RESULTS

REFERENCES

Aryana, M. (2010). Relationship between self-esteem and academic achievement amongst pre-university students. *Journal of Applied Sciences, 10, 2474-2477.*

Baumeister, R.F., Campbell, J.D., Krueger, J.I., & Kohs, K.D. (2003). Does high self-esteem cause better performance, interpersonal success, happiness, or a healthier lifestyle? *Psychological Science in the Public Interest, 4,* 1-44.

Boaler, J. (1998). Open and closed mathematics: Student experiences and understandings. *Journal for the Research in Mathematics Education, 29,* 41-62.

Bray, M.S. (2005). *Achievement of eighth grade students in mathematics after completing three years of the Connected Mathematics Project.* (Doctoral dissertation). ProQuest Dissertations and Theses. (UMI No. 3197596)

Cain, J.S. (2002). An evaluation of the Connected Mathematics Project. *The Journal of Educational Research, 95,* 224-233.

Clarkson, L.M. (2001). *The effects of the Connected Mathematics Project on middle school mathematics achievement.* (Doctoral dissertation). ProQuest Dissertations and Theses. (UMI No. 9997642)

Curtis, K.M. (2006). *Improving students' attitudes: A study of mathematics curriculum innovation.* (Doctoral dissertation). ProQuest Dissertations and Theses. (UMI No. 3215071)

Davison, D.M., & Mitchell, J.E. (2008). How is mathematics education philosophy reflected in the math wars? *The Montana Mathematics Enthusiast, 5,* 143-154.

Grouws, D.A., Tarr, J.E., Chavez, O., Sears, R., Soria, V.M., & Taylan, R.D. (2013). Curriculum and implementation effects on high school students' mathematics

learning from curricula representing subject-specific and integrated content organizations. *Journal for Research in Mathematics Education, 44,* 416-463.

Hacker, A. (2012, July 28). Is algebra necessary? *New York Times.* Retrieved from http://www.nytimes.com/2012/07/29/opinion/sunday/is-algebra-necessary.html?pagewanted=all&_r=0

Hamid, M., Sharill, M., Matzin, R., Mahalle, S., & Mundia, L. (2013). Barriers to mathematics achievement in Brunei secondary school students: Insights into the roles of mathematics anxiety, self-esteem, proactive coping, and test stress. *International Education Studies, 6.* Retrieved from http://www.ccsenet.org/journal/index.php/ies/article/view/31183

Harwell, M.R., Medhanie, A., Post, T.R., Norman, K., & Dupuis, D.N. (2012). Preparation of students completing a Core-Plus or commercially developed high school mathematics curriculum for intense mathematics coursework. *The Journal of Experimental Education, 80,* 96-112.

Hiebert, J., Carpenter, T.P., Fennama, E., Fuson, K., Human, P., Murray, H., Oliver, A., & Wearne, D. (1996). Problem solving as a basis for reform in curriculum and instruction: The case of mathematics. *Educational Researcher, 25,* 12-21.

House, P.A. (2003). Integrated mathematics: An introduction. In S. A. McGraw (Ed.), *Integrated mathematics: Choices and challenges* (pp. 3–11). Reston, VA: National Council of Teachers of Mathematics.

Klein, D. (2007). A quarter century of US 'math wars' and political partisanship. *Journal of the British Society for the History of Mathematics, 22,* 22-33.

Lappan, G., Fey, J., Fitzgerald, W., Friel, S., & Phillips, E. (1999). *Getting to know Connected Mathematics: A guide to the Connected Mathematics curriculum.* Dale Seymour Publications.

Liu, X. & Kiorala, H. (2009). *The effect of mathematics self-efficacy on mathematical achievement of high school students.* Paper presented at the Annual Conference of the Northeastern Educational Research Association, Rocky Hill, CT.

Ma, X., & Kishor, N. (1997). Assessing the relationship between attitude toward mathematics and achievement in mathematics: A meta-analysis. *Journal for Research in Mathematics Education, 28,* 26-47.

Ma, X. (1997). Reciprocal relationships between attitude toward mathematics and achievement in mathematics. *Journal of Educational Research, 90,* 221-229.

Madison, B. L., & Hart, T. A. (1990). *A Challenge of Numbers: People in the Mathematical Sciences.* Committee on Mathematical Sciences in the Year 2000, National Research Council.

Majeed, A.A., Darmawan, G.N., & Lynch, P. (2013). A confirmatory factor analysis of the Attitudes Toward Mathematics Inventory (ATMI). *The Mathematics Educator, 15,* 121-135.

Mohammad A. (2010). Relationship between self-esteem and academic achievement amongst pre-university students. *Journal of Applied Sciences, 10,* 2474-2477.

Mriano, S. (2005). *An investigation of the relationship between students' attitude toward learning mathematics and mathematics achievement with respect to gender among tenth grade public school students in Amman, Jordan.* (Doctoral dissertation). ProQuest Dissertations and Theses. (UMI No. 3186960)

National Commission on Mathematics and Science. (2000). *Before it's too late.* Washington, DC: U.S. Government Printing Office.

National Council of Teachers of Mathematics. (1980). *Agenda for action.* Reston, VA:

Author.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Research Council. (1989). *Everybody counts: A report on the future of mathematics education.* Washington, DC: National Academy Press.

Organization For Economic Cooperation and Development. (2012). *United States – country note – results from PISA 2012.* Paris, France: Author.

Ormrod, J.E. (2006). *Educational psychology: Developing learners.* Upper Saddle River, NJ: Pearson Education.

Petric, M. (2011). *Reform in mathematics education: What do we teach for and against?* (Doctoral dissertation). ProQuest Dissertations and Theses. (UMI No. 3445816)

Portal, J. & Sampson, L. (2001). *Improving high school students' mathematics achievement through the use of motivational strategies*. (Master's thesis). ERIC Full Text. (UMI No. 460854)

Randhawa, B.S., Beamer, J.E., & Lundberg, I. (1993). Role of mathematics self-efficacy in the structural model of mathematics achievement. *Journal of Educational Psychology, 85,* 41-48.

Reynolds, A.J., & Walberg, H.J. (1992). A structural model of high school mathematics outcomes. *The Journal of Educational Research, 85,* 150-158.

Rich, M. (2012, July 6). "No child" law whittled down by White House. *New York Times.* Retrieved from http://www.nytimes.com/2012/07/06/education/no-child-left-behind-whittled-down-under-obama.html?pagewanted=all&_r=0

Riordan, J.E., & Noyce, P.E. (2001). The impact of two standards-based curricula on student achievement in Massachusetts. *Journal for Research in Mathematics Education, 32,* 368-398.

Schiefele, U. & Csikszentmihalyi, M. (1995). Motivation and ability as factors in mathematics experience and achievement. *Journal for Research in Mathematics Education, 26,* 163-181.

Schoenfeld, A.H. (2004). The math wars. *Educational Policy, (18),* 253-286.

Schreiber, J.B. (2002). Institutional and student factors and their influence on mathematical achievement. *The Journal of Educational Research, 95,* 274-286.

Schommer, M. (1990). The effects of the beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology, 82,* 498-504.

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest and academic achievement. *The Journal of Education Research, 95,* 323-332.

Tapia, M. (1996). *The attitudes towards mathematics instrument.* Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Tuscaloosa, AL.

Tapia, M., & Marsh, G. (2000). *Attitudes toward mathematics instrument: An investigation with middle school students*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Bowling Green, KY.

Tapia, M., & Marsh, G. (2002). *Confirmatory factor analysis of the Attitudes Toward Mathematics Inventory.* Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Chattanooga, TN.

U.S. Department of Education. (2000). *Before it's too late: A report to the nation from the National Commission on Mathematics and Science Teaching for the 21st Century*. Education Publications Center, 2000.

Usiskin, Z. (2003). The integration of the school mathematics curriculum in the United States: History and meaning. In S. A. McGraw (Ed.), *Integrated mathematics: Choices and challenges* (pp. 13–31). Reston, VA: National Council of Teachers of Mathematics.

Vygotsky, L.S. (1978). Mind in society: The development of higher psychological processes. Cambridge, MA: Harvard University Press.

Wilkins, J.L., & Ma, X. (2002). Predicting student growth in mathematical content knowledge. *The Journal of Educational Research, 95,* 288-298.

Wood, T., & Sellers, P. (1996). Assessment of a problem-centered mathematics program: Third grade. *Journal for Research in Mathematics Education, 27,* 337-353.

Zahorik, J.A. (1996). Elementary and secondary teachers' report of how they make learning interesting. *The Elementary School Journal, 96,* 551-564.

Ziegler, J.F., & Yan, W. (2001). *Relationships of teaching, learning, and supervision: Their influence on student achievement in mathematics.* Paper presented at the Annual Meeting of the American Education Research Association, Seattle, WA.