The University of Southern Mississippi

DOES THE USE OF A GRAPHING CALCULATOR TUTORIAL AFFECT THE ATTITUDES, ACHIEVEMENT, AND CALCULATOR ABILITY OF NON-MATHEMATICS MAJORS IN A CALCULUS COURSE?

by

Kari Michelle Everett

Abstract of 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

August 2011

ABSTRACT

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The use of graphing calculators in a mathematics classroom is becoming more common place. Teaching with technology has allowed for advancements in the rapidity with which students learn and the degree to which they retain the material taught. As a result, teachers have time to delve more deeply into mathematical topics that might otherwise have merely been touched upon.

This study shows the effects of a graphing calculator tutorial for non-mathematics major students taking calculus as a required course. Qualitative methods were used in order to provide information about the types of students taking a calculus course for non-mathematic students. The tutorial was used to help the student better understand the use of a graphing calculator while learning calculus. The study tested changes in attitudes, achievement, and ability with respect to the use of a graphing calculator through the use of a post-survey, a pre/post-quiz, and overall grade comparison. The tutorial was not heavily used by the students. This finding suggests that students are not dependent on the use of a graphing calculator to better understand calculus and its applications.

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CHAPTER I

INTRODUCTION

Different technologies are used in learning environments, including simulations and visualizations, hypermedia, the Internet and World Wide Web, remote scientific instrumentation, telecommunications and computer-supported collaborative learning, and virtual and immersive environments (Web-based Education Commission, 2000). This research study will focus on the use of graphing calculators. Research has shown that students have been able to identify specific topics in which graphing calculators were helpful in better understanding an idea (Smith & Shotsberger, 1997). Alkhateeb and Wampler (2002) found that the use of a graphical approach in promoting understanding of the concept of the derivative made a significant difference in the performance of females, but not for males. Research by Waits and Demana (2000) showed that calculators cause changes in the way mathematics teachers teach and in the way students learn. Calculators and computers have enabled students to move away from the limitations of paper and pencil computations and toward the development of deeper conceptual understandings and valuable critical thinking and problem-solving skills. Students reported that they liked using the calculators in class because they believed the calculators would help them understand the mathematics more readily and that they made learning fun (Waits & Demana, 2000). Additional research also supports the benefits of using graphing calculators in the mathematics classroom (Cedillo, 2001; Garner, 2002; Graham & Thomas, 2000; Saeki, Ujlie, & Tsukihashi, 2001; Wilson & Naiman, 2004).

Before these benefits can be realized in terms of mathematics education, use of the technology must be taught. Technology skills used with graphing calculators include algebraic and graphing operations. Developed by the researcher, the tutorial, *Loving the Graphing Calculator* (http://ocean.otr.usm.edu/~w144589/webpage/tutorialhome.htm), gives students step-by-step instructions on how to perform different operations on the graphing calculator without the presence of an instructor. The tutorial provides both detailed examples and practice drills for the students to follow outside of class. Also, it allows students to have a self-paced environment and 24-hour access if they have a computer at home with internet access. The students do not have to download any software for the program, and the tutorial can be accessed globally. Students can repeat the tutorial as many times needed until they have mastered the concepts and feel confident in the use of a graphing calculator.

The tutorial was developed over a two-semester period by the researcher. It was designed for students enrolled in *Brief Applied Calculus*, a course required for business majors at The University of Southern Mississippi. Mathematics majors do not take this course. Students learn to work derivative and integration application problems with respect to instantaneous rates of change and slopes of curves. Two to four sections of the course are offered every semester with face-to-face instruction by several different instructors. Some instructors require the use of graphing calculators while others do not. The tutorial started as a Microsoft PowerPoint ™ presentation and evolved into a Web application with a target demographic of Texas Instrument graphing calculator (TI 83 and 84) users. Being able to see the instructions coincident with relevant images of the calculator screen helps students better understand the use of the graphing calculator with respect to calculus. Being Web-based, the tutorial can be easily used in concert with online quizzes and other resources.

Problem Statement

In this study, the researcher proposed to evaluate the effectiveness of the tutorial based on use in one section of *Brief Applied Calculus*. This section was not taught by the researcher. Students' attitudes and achievement were investigated to determine whether the students with access to the tutorial exhibit different results from those without access to the tutorial on pre- and post-quizzes, an attitude survey, and an end of course survey. The study proposed that students who use the Web-based graphing calculator tutorial will demonstrate higher achievement and have a significantly more positive perception of mathematics.

Purpose of the Study

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

1. Does the use of a tutorial for graphing calculators help students better understand how to use the derivative and integration functions of a graphing calculator based on pre-test versus post-test scores?
2. Does the use of the tutorial change a student's attitude towards graphing calculators and mathematics based on an attitudinal survey?
3. Does the use of the tutorial change a student's overall achievement in the course based on end of course grades?

Theoretical Framework

The fields of mathematics and mathematics education are in the midst of a paradigm shift. Traditionally, the philosophy of mathematics has been approached from an absolutist point of view in which mathematics is described as a source of secured knowledge with little changing (Ernest, 1998). Social constructivism identifies mathematics from human problem posing and solving perspectives (Ernest, 1991). Waxman, Williams, and Bright (1994) describe four areas of research that have implications for the future of mathematics education. The areas include the cognitive psychology perspective, staff development and training, evaluative research studies, and programmatic research. The cognitive psychology perspective views mathematics as a means of learning to understand when and how to use problem-solving strategies. Cognitive psychology views learning as an active process and teaching as a means of facilitating active student mental processing (Waxman, Williams, & Bright, 1994). Research on cognitive strategies for calculators indicates that more information is needed on how calculators affect existing differences among teachers and students, and that researchers also should examine cultural, gender-related, grade-related, and ability-related differences in calculator use (Blechle, 2008; Haciomeroglu, 2008; Oppland, 2011). Multiple representations in symbolic, visual, and verbal forms help to show students how to process information. Moreno and Mayer (2000) focused on the number line as an appropriate model for integer addition and subtraction. They examined the effects of computer-supported visual and verbal representations of the execution of computational procedures when using a number line. The findings of the research support the use of multiple representations to help students learn mathematical procedures. Additionally, students who possess a good basic knowledge of a concept benefit from multiple representations, especially with difficult problems. This suggests that students who are less well-versed in the concept will derive greater benefit from multiple representations of concepts. Finally, for instructional materials to be effective, learning differences for individuals must be considered. Mathematics offers real-world problems that are long-lived challenges and remain unsolved, but are of great interest to people for many years. Yet, the development of new techniques to solve some of these problems changes mathematics and serves as a catalyst for the growth of mathematics knowledge. Technology has helped change mathematics. With the introduction of computers and graphing calculators, more advances in mathematics have been possible.

Lerman (2000) identifies four reasons why different disciplines are drawn upon in the mathematics education research community. They include the status of mathematics as a body of knowledge and as a set of social practices that has been and remains of particular interest to other disciplines as it presents challenges to their work; that mathematics has stood as exemplar of truth and rational thinking since ancient times; the mathematics has played a large part in diverse cultural practices; and finally, that there is the apparent power of mathematics. Mathematics continues to change and research continues to allow for those changes.

Justification for Online Tutorial

The zone of proximal development by Vygotsky defines those functions that have not yet matured but are in the process of maturation. Collaboration with another person in the zone of proximal development thus leads to development in culturally appropriate ways. Specifically, the concepts make more sense when explained by a peer or someone with a similar cultural background who can relate to the experience of the learner (Trudge, 1990). In order to determine the nature and path of development, the type of instruction and the social environment in which the development occurs must be examined. Development of a student is influenced by his/her surroundings. Culture influences how a student perceives the value of society and education. Therefore, a student who does not initially perceive tutorials as necessary or useful, but upon seeing the success that a classmate is having, may rethink his/her position on the value of tutorials. In Vygotskian terms, the impact of the social context has an immediate, lasting, and powerful effect on the student (Trudge, 1990).

The availability of online resources has caused educators' attention to be shifted to computer-assisted and online learning for students (Baily et al., 2001). Studies have shown that students' learning can be enhanced by online supplements (Bliwise, 2005; Firth, Jaftha, & Prince, 2004). The Web-based Commission Report (2000) indicated a steady growth of online courses in K-12 and postsecondary education. They also found that the Internet offered education in places where there may not be any formal structures, and extended education in places where there were few resources. Also, the report stated a need for new educational designs to achieve learning in the market and global economy.

At the postsecondary level, colleges and universities are using the Internet as an educational resource tool (Web-based Education Commission, 2000). With this, teachers and students are better prepared for the workforce and can understand the uses of the Internet for their chosen profession. Students understand the applications of technology when shown examples of correct usage in different settings (Web-based Education Commission, 2000). The tutorial for this study was started as a project for an instructional technology course which explored the need for a Web-based tutorial for students. The need exists for a tutorial on graphing calculators for non-mathematics majors who are taking a calculus-based course that emphasizes the use of graphing calculators.

Definition of Terms

Key phrases pertinent to the study were defined as follows:

1. Graphing calculator: Refers to a handheld calculator that is capable of plotting graphs, solving simultaneous equations, and performing numerous other tasks with variables;
2. Web-based Tutorial: *Loving Your Graphing Calculator*, an on-line tutorial developed by the researcher;
3. Attitude: Thoughts and feeling toward mathematics;
4. Achievement: Overall grade in the mathematics course;
5. Integration: The method used to find the area under a curve and is the second main branch of calculus; and
6. Derivatives: The method used to calculate instantaneous rates of change, investigate the slopes of tangent lines and the first main branch of calculus.

Study Delimitations

The study had some delimitations that could have had an influencing factor in the results of the study's findings and conclusions due to the constraints set by the researcher.

The delimitations occurred because the requirements for the students taking the course and the number of sections offered each semester. These three delimitations were:

1. The subjects for the study were students enrolled in MAT 102: Brief Applied Calculus during one semester taught by one instructor.
2. The majority of the students were business majors enrolled at The University of Southern Mississippi.
3. The researcher created the tutorial and quiz for the study.

Summary

The study of graphing calculators and their impact upon classroom performance has been ongoing for the last 20 years. Technology, when well integrated in the classroom and used effectively, can improve student learning in mathematics. Despite this, the impact of tutorials has not been as widely studied for graphing calculators. This may be due to the involved explanations that students receive in class for the concepts that are being taught. Tutorials in general are being used for social sciences and humanity courses at the college level. These tutorials are generally Web-based and often used as a course supplement. Students are not required to use the tutorials, but it has been found student achievement increases with the use of the tutorials. The overall purpose of this study is to demonstrate that students who use Web-based tutorials display increased achievement for a mathematics course. The next chapter is a review of literature that addresses research studies that have been performed concerning the use of technology in mathematics instruction. This overview provides a foundation for examining Web-based tutorials on calculator usage in college mathematics courses for this particular study.

CHAPTER II

REVIEW OF RELATED LITERATURE

Why is technology and its applications important in mathematics education? What are the goals of using technology in mathematics? How has technology been integrated into the mathematics classroom? Mathematics education brings many different aspects of technology to the table. Technology in the classroom has spread throughout education in the United States. This technology includes multimedia equipment used in the everyday curriculum. Multimedia practices are expensive to implement into the curriculum, because the education enterprise has to supply the equipment and train the faculty. Technology should be used to create lasting benefit, and not just for immediate success. Students need not only computer literacy, but also enough proficiency to understand the mechanics of the applications. According to the National Council of Teachers of Mathematics (NCTM, 2000) technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning. As long ago as 1968, *Your Child and Mathematics* informed parents:

> Whether we like it or not, our children will be concerned in the future with more abstract mathematics than their predecessors. The world of computers and computer programs, of automatic production line processes, or of operational research by management, is a far cry from the world of the nineteenth-century clerk, mill-hand, or small industrialist. Our most important task must be to teach children to think mathematically for themselves. From a gradual awareness of the

> patterns of ideas underlying their practical experiences, there must be built up a willingness to accept the underlying mathematical ways of thinking which are proving so vital in the development of modern technological society (Marshall, 2003, p.194).

The mathematics reform movement is a result of national and international studies. Such studies have indicated that American students are not performing at the same level as other countries with respect to problem-solving and higher-order thinking skills. Education reform goes back as far as education itself. Starting with the Committee of Ten on Secondary School Studies, educators have attempted to reshape school mathematics programs since the early 1900s. The College Entrance Examination Board and the American Mathematical Society also attempted to change the mathematics curriculum. In 1908, the International Commission of the Teaching of Mathematics stimulated efforts for change in mathematics. Despite all these efforts, there were no national organizations to lead and coordinate the efforts of local and regional associations (Kilpatrick & Silver, 2000). Some of the most notable reforms came in the 1950s and 1960s with the "new math" movement, the 1970s with the "back-to-basics" movement, and with the 1980s curriculum reforms. The purpose of the "new math" movement was to train students to become better scientist and mathematicians. The movement took place during the space race era when the United States did not want to lag behind the Soviet Union. The federal government funded programs for new mathematics curriculum materials and teacher training to use these materials in the classroom. Teachers, parents, and students did not respond favorably to the new curriculum. In response, the 1970s saw the development of the back-to-basics movement, which focused on addition, multiplication, and problem solving. By the late 1970s, educators realized that the basics were not enough; students needed to know not just how to compute, but when to use the different computations (Findell, 1996). With the latest rounds of reforms, one of the greatest challenges is to find a teaching method that develops understanding of mathematics rather than rote memorization of the facts (Marshall, 2003). Some mathematics educators want to move away from teacher-centered learning to student-centered learning by using the constructivist teaching paradigm. This new mathematics curriculum would challenge the beliefs and routine of traditional mathematics in order for students to gain meaningful, lasting and useful mathematical knowledge (Draper, 2002). The role of a constructivist teacher is to observe students in order to create an environment with opportunities for students to construct knowledge while asking questions. Within mathematics classrooms, graphing calculator explorations allow teachers to organize students in groups focused on student-centered learning activities.

Graphing Calculator Usage in Mathematics

The habit of mathematical reasoning needs to be fundamental skill taught throughout mathematics education (Dugdale et. al., 1995). Spending elementary and middle school years on rote memorization practices does not help students to become proficient in mathematical reasoning once they reach high school algebra. The mathematics classroom has changed throughout the years. Signs of increased use of technology to help students develop their reasoning skills are more visible. Technology appears in the classroom in the form of computers and graphing calculators. These tools have the potential to positively impact a student's mathematics learning and success.

One effect technology has had on mathematics, particularly in algebra and calculus, is the ability to visualize concepts differently. For example, in calculus, educators want to increase the use of computer algebra systems (CASs) to increase student engagement with the concepts, use of problem-solving models, and communication both within and outside mathematics. An important goal for teaching mathematics with the CAS is to design courses like calculus and algebra so that students can become active participants in the planning and execution of problem-solving strategies (Leinbach, Pountney, & Etchell, 2002). CASs are a tool to assist the students in problem-solving. The system does not take the place of teaching problem solving processes, but serves as a reference book with the answers. CASs allow students to enter a function into a graphing calculator or computer software, and provide the answer. CAS do not offer information as to the solution process. This requires the use of problem-solving drills to ensure students understand how the answers are derived. The design of technological tools and learning environments also impact students. The computational, visual, and interactive nature of computer environments enables the creation of new ways of observing and investigating mathematical behavior. Computer problem-solving activities help students to understand the limitations they may encounter with technology (Dugdale et. al., 1995).

There are many vectors for research on how technology is used in the classroom. Jacobson, Angulo, and Kozma (2000) see four main strands in research into the design and use of technological learning tools. They include representation and symbols, design of technological tools and learning environments, collaborative interactions and learning communities, and assessment and learning process. Different technological tools are used in the learning environments including simulations and visualizations, hypermedia, and the Internet and World Wide Web. With these tools, students are able to model, reflect, and generalize about problems they are working on and transfer what they learn to other situations and concepts. Students must be given precise instructions with respect to algebraic symbols when using technological tools like a graphing. For example, students must know when to use the negative sign or the operation of subtraction. To a graphing calculator, the signs invoke different operations even though they look alike. Students also must know how to graph on graphing calculators, and concepts that enable use of the graphs. Knowing how to navigate between windows on the calculator to have a better view of a graph is essential. Calculators allow students and teachers an opportunity to explore some mathematical ideas further than they would have otherwise due to the graphing calculators' capabilities. Calculators allow students to repeat operations easily, enabling exploration into the study of dynamic systems complex numbers. One purpose of technology is to allow students to explore and conjecture (Burrill, 1992). Students need to be able to investigate problem spaces, experiment with solutions, and discover mathematical relationships in problems. Teachers need to make sure students know how to use their calculators effectively to have a better understanding of mathematics.

In their chapter on *Research on Calculators in Mathematics Education*, Hembree and Dessart (1992) found seventy-nine reports of experiments and relational investigations about calculator usage. In these studies, one group of students was permitted calculator usage and another group was not for thirty school days. The findings indicated that scores improved for low- and average-ability students with calculators. None of the studies provided data on high-ability students in computation, but scores in problem-solving showed a moderate improvement with calculator use. There was no apparent effect for low- and average-ability students in either computation or problem-solving without the use of calculators. Results were also gathered by surveys involving the following areas: policies toward calculators use, the accessibility of calculators in schools, modifications to the curriculum due to calculators, and students' attitudes toward the devices. Sixty-four percent of states have recommended calculator use for instruction in high school and the availability of calculators has increased due to a decrease in cost. States are including the technology in their curriculums and encouraging teacher professional development to develop calculator proficiency. This enables teachers to use different educational activities with the calculators. Students like using the calculators in class because they believe calculators will help them understand mathematics more and make learning more fun and interactive (Waits & Demana, 2000).

Students want mathematics to be more fun. Teachers respond to this desire by changing their instructional practices and supporting learning both in and outside the classroom. Waits and Demana (2000) determined that calculators cause changes in the way teachers teach and in the way students learn. Calculators and computers enable students to move away from paper and pencil computations and to develop deeper conceptual understanding and valuable critical thinking and problem-solving skills. They also found that calculators reduce the drudgery of applying arithmetic and algebraic procedures when those concepts are not the focus of the lesson. In addition, calculators with interactive geometry allow for investigations that lead to a much better understanding of geometry. Calculators also help students see that mathematics has value, and a graphing calculator makes graphical and numerical representations practical learning strategies. Before calculators, students studied calculus to learn how to obtain accurate graphs. Doerr and Zangor (2000) found the graphing calculator plays different roles as a tool for students including computational, transformational, data collection and analysis, visualizing, and checking. In their study, Doerr and Zangor (2000) observed students routinely using the calculator to evaluate numerical expressions and to perform routine task interpreting graphs and data. Students also used the graphing calculator to collect and analyze data using Computer Based Labs (CBLs). Students were observed repeating experiments to obtain the pattern they expected to see with the experiment. The students also used the graphing calculator as a visualization tool to view graphs correctly, solve equations, and link visual representations of data to best fit equations. The researchers concluded that the graphing calculator is a multidimensional tool which helps students understands content, but that can hinder student learning by fostering a dependence on the device.

Educators also have to pay attention to assessment. Calculators are being used in both classroom and standardized test assessment. This use raises the issue of how much data a student should be required to record when working problems with a calculator. Teachers need to be aware of the uses of calculators in assessment, and the assessments need to be more focused on professional development activities in order for teachers to understand how to update curricula so that students can be adequately assessed. Romberg (1994) identifies nine issues dealing with assessment that must be addressed in order to effectively reform assessment practices. The issues include questioning the underlying assumptions about the nature of mathematics and mathematics learning, the need for new psychometric models, alignment with the reform curriculum, specification of performance standards, developing authentic tasks, measuring status, growth, or a combination, scoring, and making reports of results understandable to the public. These issues could be addressed with a new curriculum modified for the use of technology. Teachers are allowing calculators to be used as both a part of the classroom routine and with assessments. This has created apprehension that CAS calculators will require recreation or modification of the entire test. Teachers need to know how to phrase problems and questions to neutralize student reliance on calculators. Fears about technology need to be understood and addressed (Waits & Demana, 2000). The CAS makes manipulations easier and more accurate than paper and pencil. Students who use these tools will require change in many aspects of mathematics including the curriculum test and learning expectations. Teachers who do not embrace the changes will be left behind as they fear what they do not understand. Students will continue to use computers and calculators for many activities including communicating, collecting and analyzing data, modeling real-world problems manipulating mathematical expressions, and displaying information graphically (Kilpatrick & Silver, 2000). Through these activities educators believe that students will have a better understanding of mathematics and that some misconceptions will be cleared.

What does the future hold for technological tools in the mathematics classroom? Educators need to evaluate tools from the perspectives of both professional development and future curriculum requirements. Findell (1996) states that if today's classrooms are to become more student-centered, then the teacher should no longer act as a dispenser of knowledge, but as a facilitator of knowledge, allowing students to make sense of what they are learning. Educators and researchers alike must remember that teachers will require training on the use and implementation of new technology. If educators expect teachers to integrate technology into their classrooms, then teachers must be supported with continuous training about the new teaching and assessment methods mandated by the new technology. Increased emphasis needs to be placed on research on the use of calculators and their effectiveness. Similarly, research on the effectiveness of technology in the mathematics classroom needs to be more focused on the methods and pedagogy. This is especially true when a new curriculum is written to incorporate technology across the mathematics education spectrum.

Technology allows the exploration of in-depth concepts by teachers and students in a manner not previously possible. Technology creates an additional path for students to excel in mathematics beyond paper and pencil techniques. It enhances students' understanding of mathematical reasoning and problem-solving. Reform in mathematics education has led to the need for a curriculum integrating mathematics and technology. The goals of technology incorporation within mathematics education include having appropriate assessment mechanism for technological tools in mathematics; having an integrated curriculum with mathematics and technology; having research to support technology in mathematics education; and having mathematics reasoning and understanding using technology. In Choi-Koh (2003), the researcher examined a secondary student's thinking within a technology-based environment while he learned mathematics. The study consisted of seven tasks and was conducted from May to June 1998. Data collection included observations of instructional tasks, clinical interviews with the student and an audiotape of his learning process. Sung Min's (a pseudonym) reasoning was based on numerical and visual data in the calculator. The use of technology helped the student advance his or her thinking process from the intuitive to the operative, and finally to the applicative stage. According to Cedillo (2001), the study provided evidence that through numerical explorations, the students could assign meanings to algebraic code without needing previous knowledge of definitions and syntactical rules. This suggests that the students were learning algebra by using algebra. The research was carried out within the clutter of the mathematics classroom and took place in a private school. The researcher acted as the experimental group's mathematics teacher over the school year. This study changed the method of teaching of algebra and a student's conceptual knowledge of mathematics. A key factor in the development of the notion of a letter as a symbol representing any number and of algebraic expressions as computing devices was the use of the calculators to describe the general behavior of numerical patterns. Eighty-eight percent of the students from Cedillo's (2001) study were able to do this. Students developed well-formed notions concerning algebraic equivalence based on their explorations of the numerical values of algebraic expressions.

The simplification of similar terms was the only kind of task in which the students tended to display misconceptions. Despite the fact that the majority of the students could not find systematic ways to invert a linear function, all the case-study participants demonstrated that they understood the purpose of inverting a function. Students' responses provided empirical evidence that led the researchers to affirm that the students were capable of dealing with symbolic manipulation of the kind included in questions like, "I wanted to type in the program b x 8 but I made a mistake and instead of this I put in b x 7. Can you change this without erasing anything I wrote?" The data gathered also showed that 96% of the students were capable of using the calculator code to deal with problems whose solutions could be obtained algebraically. Visual patterns and simple geometrical relations helped students obtain equivalent algebraic representations according to problem constraints. When working with the calculator, students are forced to think about which operations must be carried out with the input number to obtain the output number. Graham and Thomas (2000), like Cedillo (2001), investigated the concept of variables to further students' progress in algebra. The difference in the studies is that Cedillo's students had not been exposed to algebra yet, but Graham and Thomas's students were in the early stages of studying algebra. Graham and Thomas's (2000) classroom-based research project "Tapping into Algebra" was designed to compare the teaching of variables in algebra with and without the use of graphing calculators. One of the teaching aspects of the module was the use of screensnaps, where students were given a screen and required to reproduce it on their calculator screen. The results showed that the students who had used the graphing calculators had performed significantly better on the post-test than the non-graphing calculator students. The majority of the students felt that the experience of using the graphing calculators benefitted them in improving their understanding and making the learning of algebra fun. According to Moschkovich (2004), the study examined how a student appropriated aspects of mathematical practices while working with functions. The sessions combined interviewing and tutoring, eliciting the student's own understandings while providing guidance and assistance. Initially the tutor was more active in setting goals, yet as the student gained more experience with the subject matter, she increasingly generated and pursued her own problems.

Saeki et al. (2001) used a cross-curricular course for first-year and second-year students. The course integrated a Computer Based Laboratory (CBL) and a graphing calculator (TI-83) for students to learn about the connections between mathematics and physics. When students completed the experiments, they replaced their naive assumptions regarding the laws of physics with scientific concepts. Twenty-six percent of the students reported a change in the interest in science compared to 52% whose interest did not change. Forty-eight percent of the students agreed that mathematics is more important than believed. The use of the CBLs and TI-83s changed not only the author's teaching style, but also students' attitudes about mathematics and science. In Garner (2002), the author explores her experience in a classroom using computer algebra systems (CAS) and how it changed her teaching methods and the attitudes of students. The use of CASs in the mathematical methods subject provided an opportunity to assess the impact of CAS use on all aspects of teaching, learning and assessment. The use of

CASs also changed the curriculum to reflect differences in student testing. These studies indicated changes in curriculum and student learning change due to CAS, a mathematics technology.

Hollar and Norwood (1999) extended a computer-intensive algebra study by investigating the effects of a graphing-approach curriculum employing the TI-82 graphing calculator. The experimental class had a significantly better overall understanding of functions. There was no significant difference between scores of treatment and control classes. One instructor's students had a slightly higher mean score than the others. The attitude survey showed that students in the experimental class had slightly more positive attitudes than the other students about mathematics and their mathematical ability. The graphing calculator allowed the students to create equations, tables, and graphs easily and to move between the representations rapidly. Similarly, in Hennessy et al (2001), the researchers investigated the use of graphing calculators by undergraduates taking an innovative new mathematics course at Open University. They were interested in the influence of graphing calculators on mathematical thinking. Many students stated that their use of the graphing calculator increased their confidence level. The graphing calculator also altered the attitudes of students towards mathematics.

Web-Based Mathematics

Web-based mathematics is growing in post-secondary as well as secondary schools. Virginia Polytechnic Institute and State University (Virginia Tech) developed their Math Emporium from a 1997 pilot study in the mathematics department. Three overarching goals were set for the Math Emporium: (a) to challenge students and assist them to become active learners, (b) provide multiple ways to accommodate student learning, and (c) provide appropriate and adequate resources. In her article, Moore (2001) described the features that made the Math Emporium a success for students. The Math Emporium consisted of a 56,000-square-foot facility containing over 500 computers with online learning via tutorials, tutors, lectures on CD-ROM, group meetings, and live lectures. Through the different learning situations, students were able to achieve the goals set before them in a mathematics course. The Math Emporium faculty was successful in their implementation of Web-based instruction for Math 1114: Linear Algebra, which represented an approach other than lecture to teaching linear algebra. The faculty transformed the course into a Web-based resource system that includes interactive tutorials, electronic homework assignments and HTML textbooks, online quizzes and tests, and a database for students' records. The mathematics department continues to update and improve the instruction for the mathematics courses they teach within the Math Emporium.

Baily, Hall, and Cifuentes (2001) performed a study to examine the impact of nine Web-based modules on learning as measured by both online module quizzes and in-class exams in two college level mathematics courses. The modules were designed to support fundamental concepts in low-level college mathematics courses. The goals of this study were to answer the following questions:

- How does the use of the nine Web-based learning modules designed to support fundamental concepts in entry-level college mathematics courses impact student success on in-class tests and quizzes?

- What are some of the characteristics of learners who exhibit satisfactory performance on both the Web-based learning modules and in-class test and quizzes?
- What are some of the learning strategies used by learners who exhibit satisfactory performance on both the Web-based learning modules and in-class quizzes and tests?
- What are some of the characteristics of learners who exhibit unsatisfactory performance on both the Web-based learning modules and in-class tests and quizzes?
- What are some of the learning strategies of learners who exhibit unsatisfactory performance on both the nine Web-based learning modules and in-class tests and quizzes?

Findings indicated that students who scored above 80% on the module quizzes also did better on in-class exams and the final course average. Based on in-class surveys and follow-up interviews, results indicated that those who were self-motivated, focused and self-disciplined, had greater success in the online environment than students who participated haphazardly. This study showed that the Internet can be a powerful tool for learning in the classroom. The characteristics of students who were successful in the study identify what traits students must possess to be successful when using Web-based instruction. This study helped to show that students must be strong self-motivators in order to be successful in online courses. The study also indicated that students need a strong support base to be able to be successful in online classes.

Engelbrecht and Harding (2005) identified four case studies in Web-based mathematics instruction from various universities in the U.S. The first case study, the NetMath Project from the University of Illinois Urbana-Champaign, offered various online courses conducted via Mathematica notebooks with assistance from a support team. The consortium also included Ohio State University, the University of Pittsburgh, the University of Iowa, and Harvard University. The program included the basic mathematics courses, as well as differential equations, linear algebra, and probability theory. The second case study at the University of Pretoria studied various online courses including Web-based calculus courses. The calculus courses ran on a WebCT platform and the student was guided day-by-day through the lessons and discussion sessions. Students turned in four assignments and one project during the semester in hard copy using MathLab or Maple. The third case study involved the use of notice boards for course supplements at the State University of New York at Stony Brook. The last case study involved a resource site for a project based at Duke University, Connected Curriculum Project. The site projects offered various resources for students as supplements for courses taught using traditional lecture methods.

The existing research on online mathematics shows that there are various programs available for students to use, and those universities are making progress in identifying requirements for an online mathematics course. Online courses emphasize the need for tutorials. These tutorials are Web-based, making the medium easier for students to access them outside of the classroom. This allows for the teacher to be able to concentrate on new concepts rather than having to spend time reviewing old concepts and teaching tool manipulation.

Web-Based Tutorials

The availability of online resources has caused educators' attention to be shifted to computer-assisted and online learning for students (Baily et al., 2001). Students have shown that learning can be enhanced by online supplements such as Web-based tutorials (Bliwise, 2005; Firth, Jarfth, & Prince, 2004). Early tutorials used the Latex2HTML convertor to place math content on the Web. Recently, alternatives have appeared and advances in mathematical typography has allowed for full mathematics course content including Web features such as animations, graphics, online assessment and interactivity (Allen, 2003). Web-based tutorials have been developed as supplements for courses in the sciences and humanities. Research has shown interactive Web-based tutorials help students learn concepts (Allen, 2003; Bliwise, 2005; Firth, Jarfth, & Prince, 2004).

Research has also indicated that effective use of multimedia can increase student learning (Aberson et al., 2000; Baily et al., 2001; Bliwise, 2005; Firth, Jaftha, & Prince, 2004; Fletcher-Flynn & Bravatt, 1995; Forsyth & Archer, 1997; McNeil & Nelson, 1991). Multimedia uses include computer demonstrations of labs, online tutorials, and online homework. Students give favorable reviews to online tutorials and course supplements which are helpful in reinforcing the material and reviewing key topics. Also, students prefer the interactive nature of multimedia, the ease of use, and the graphical presentation of the material.

Bliwise (2005) developed tutorials for five topics based on prior course evaluations in which students had identified concepts they found difficult to learn. The tutorials included an auditory explanation, animated demonstrations, summary pages of key concepts, practice problems, navigation instructions, goals of the tutorial, and a quiz to test mastery of the concepts. The tutorials are structured so students can easily navigate between components. The practice problems provide immediate feedback and offer explanations for each incorrect answer in order for students to review relevant material. Each tutorial topic was addressed during lecture and lab time on a weekly basis making the tutorials serve as a course supplement for instruction. Extra credit was given to students who took an online extra credit quiz. The results of the study (Bliwise, 2005) indicate that students who used the tutorials throughout the course were more successful on the test when taking the tutorial quizzes before taking the test. The students' evaluations of the tutorial were positive, and described using the tutorial mainly for test preparation. The strongest components of the tutorial ranked by the students were the practice exercises, explanation on concepts, visual presentation of material, ability to review many times, and earning extra credit points. The only limitation of the study was imposed by Blackboard due to records of student access to site only, and not the duration of use or movement within tutorial. Nonetheless, the access data was consistent with student usage and their descriptions of engagement.

Aberson, Begier, Healy, Kyle, and Romero (2000) also found evidence in which an interactive Web-based tutorial can help students better understand a statistical concept compared to a standard lecture or demonstration. The Web Interface for Statistics Education (WISE) project provided Web-based tutorials requiring only a Java-enabled browser for students learning about sampling distributions. Assumed with the tutorial is that the students using it have a basic knowledge of sampling, means, and normal distribution. The students liked the tutorial and its ease of use as well as its interactive nature because it gave them control over the learning process. The pre-test and post-test results showed the tutorial was as effective as the lecture and demonstration. Students enjoy using the Web and learning using Web-based tutorials according to research (Baily et al., 2001; Mitchell, Chen, & Macredie, 2005). Mitchell et al. (2005) were able to show a significant increase in performance on a module dealing with computation and algorithms from pre-test to post-test thus showing a relationship between Web enjoyment and attitudes towards Web-based learning. Students who did not enjoy the Web as much did not perform as well on the test as those who did enjoy the Web. Wilson and Harris (2002) tried to determine if the Web site, *The Psychology Place*, was an effective learning tool for students enrolled in an introductory psychology course. The Web site had various learning activities, and five were chosen for students to complete. The activities include reading, interactive tutorial and open-ended questions about the activity. Students who participated in the learning activities scored better than those who did not. The results of the study indicated that the activity improved understanding of the material and retention of concepts being tested on quizzes. Therefore, the use of Web-based tutorials does help students retain information. With increased retention of information, student attitudes changed from the negative to the positive about mathematics (Aberson et al., 2000; Forsyth & Archer, 1997; Mitchell et al., 2005; Wilson & Harris, 2002).

Attitudes toward Learning Mathematics

Attitudes towards mathematics have not always been positive. Yet, research has shown if students are given the chance to understand a mathematical concept's background, they will have a better attitude towards mathematics (Pierce, Stacey, & Barkatas, 2007; Ruffell, Mason, & Allen, 1998; Oppland, 2011; Townsend & Wilson, 2003; Yusef & Tall, 1999). Problem-solving, cooperative learning, and tutorials have helped improve students' attitudes toward mathematics. Lectures seem to bore students and do not improve the students' attitudes towards mathematics and can frustrate students into not wanting to take any other mathematics course (Yusof & Tall, 1999).

Yusof and Tall (1999) studied whether problem solving would change student's attitude about mathematics positively. The research revealed that as students were working on concepts using problem-solving, attitudes towards mathematics changed. When students returned to normal lecture courses, the negative attitudes returned. Student comments received six months after the problem-solving course indicated that students like being able to talk about mathematical concepts when learning. This allows them to better understand the process behind the mathematical concept being taught. With the lecture course, students felt rushed through the material and had no time to understand the process behind the concepts, resulting in the return of the negative attitudes. These findings showed researchers that problem-solving can change attitudes about mathematics and that lectures produce negative attitudes due to pace (Yusof & Tall, 1999).

Teachers have an influence over student attitudes toward mathematics (Ruffell, Mason & Allen, 1998; Yusof & Tall, 1999). In their research, Ruffell, Mason and Allen (1998) aimed to find an instrument which would allow teachers to inquire about students' attitudes in mathematics courses in order to better understand what instruction is effective. The researchers conducted eight studies involving children, undergraduates, trainee teachers, and experienced teachers. The studies showed that attitudes can mean different things depending on the age group. Children's attitudes vary depending on what was being studied but overall were positive. The university students identified particular experiences, good and bad, to explain their attitudes toward mathematics. They sometimes used specific examples from the past to explain their likes and dislikes (Ruffell, Mason, & Allen, 1998). The attitudes of teachers also lead to students developing similar attitudes based on what they see and do within the classroom. In a similar study (Pierce, Stacey, & Barkatsas, 2007), the researchers developed the *Mathematics and Technology Attitudes Scales* (MTAS) to monitor different variables that affect learning mathematics with technology. The sub-scales measure mathematics confidence, confidence with technology, attitude to learning mathematics with technology, and two aspects of engagement in learning mathematics (Pierce, Stacey, & Barkatsas, 2007).

Attitude changes for students introduced to flexible learning environments and tutorials for mathematics courses have been noted (Cybinski & Selvanthan, 2005). With flexible learning, students used computer managed learning tools and optional meeting groups to complete a statistics course. The question researchers were trying to answer was whether the learning mode, previous mathematics experience, and student preconceptions about statistics would affect learning enjoyment, assessment anxiety, and performance outcome (Cybinski & Selvanthan, 2005). The study found that the flexible delivery mode produced higher level of performance anxiety and less enjoyment than the traditional lecture. This is different from previous studies (Ruffell, Mason & Allen, 1998; Yusof & Tall, 1999). The researcher believes that this is due to the continuous

Web assessment for the flexible learning students. Web-based materials can be beneficial to students depending on the specific implementation.

Baki and Guveli (2008) worked with ninth graders on the concept of mathematical functions using Web-based mathematics teaching (WBMT) material. The WBMT materials used were divided into tasks that allowed students to engage in examples and interactive exercises in measured steps that allowed for better understanding. The main purpose of the study was to examine the effects of the WBMT materials on the ninth grader's achievement and attitudes toward WBMT. Students who used the materials improved significantly over those who did not use the material. Once students were used to the WBMT, they became more confident about the mathematics they were learning. Comments about the material were positive from both the students and teachers. There were improvements in students' attitudes and achievements after using the WBMT material.

Townsend and Wilton (2003) focused on two dimensions of attitude in their study of college students in an educational psychology course. The dimensions were mathematics self-concept and mathematics anxiety. Mathematics self-concept refers to "perceptions of personal ability to learn and perform tasks in mathematics" and mathematics anxiety refers to "feelings of tension that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary and academic situations" (Townsend & Wilton, 2003, p. 474). The researchers used a cooperative learning intervention to find possible influences to the attitudes. Students were divided into groups to explore different problem-solving approaches to understand the concepts being taught in the course. Attitudes were more positive at the end compared to the beginning.

Mathematics has not always been a favored subject. Attitudes vary with students and teachers depending on the situation within the mathematics course or concept being taught. Technology infusion has led to Web-based mathematics as well as online tutorials. Web-based tutorials or instruction helps to change the attitudes of students towards mathematics (Pierce, Stacey, & Barkatas, 2007; Ruffell, Mason, & Allen, 1998; Townsend & Wilson, 2003; Yusef & Tall, 1999). With the introduction of technology into the curriculum across grade levels, students are having a more enjoyable time learning mathematics.

Summary

Research in mathematics education has been ongoing for many years. Technology has made an impact on education allowing for advancement in teaching of mathematics. Teaching with technology has allowed for advancements in student learning and has allowed teachers to delve deeper into some mathematics topics. Online tutorials have helped students to better understand concepts in courses including statistics, psychology and mathematics by allowing for review of material at the student's own pace. The next chapter discusses the overall approach and methodology used to investigate the use of Web-based tutorials in assisting college students to learn mathematics skills. Information such as the participants involved, the use of instruments for data collection, and procedures used to perform the study are covered.

CHAPTER III

METHODOLOGY

This study shows the effects of a graphing calculator tutorial for non-mathematics major students taking calculus as a required course. The study compares changes in attitudes, achievement, and ability in graphing calculator knowledge by taking an attitude and end of course survey, a pre- and post-quiz, and overall grade comparison. The survey was conducted at the end of the semester given by the researcher. The pre-quiz was given at the beginning of the semester by the course instructor and the post-quiz was given at the end of the course by the researcher. An interview with the course instructor was completed during the fall semester following the end of the study. A case study approach was undertaken within a brief applied calculus course for non-mathematics majors in the mathematics department at The University of Southern Mississippi during the summer of 2010. The descriptive statistics reported on are classification, gender, and age of the sample.

Data Collection

A case study with a multi-modal approach with quantitative methods was used in order to capture the information about the students taking a calculus course for non-mathematic students. The multi-modal approach included end of course and attitude survey, pre-/post-quiz, an instructor interview, and a classroom observation. Information about gender, classification, and age was gathered with an end of course survey.

The following steps were used in the collection of data:

1. An application for approval were sent to The University of Southern Mississippi

Human Subjects Protection Review Committee to use that data and to administer pre-test, post-test, pre-survey, and post-survey in the Fall of 2009 (see Appendix A).

2. A letter was sent to the class instructor to request a copy of the MAT 102 final exam scores, gain scores of pre-quiz and post-quiz, student rosters before and after the drop date of the class and a copy of the syllabus given to the students at the beginning of the semester (see Appendix B).
3. Results on attitudinal survey (see Appendix C) conducted in the Summer of 2010 were collected.
4. An interview with the professor was conducted in person by the researcher during the Fall of 2010.

Participants

The participants were college students from traditional and non-traditional backgrounds enrolled in MAT 102, Brief Applied Calculus taught by the same professor who had been teaching this course on a regular basis. The students had the option of participating in the study for the course. Those who chose not to participate had the option of completing a different pre- and post-quiz that did not include questions about graphing calculators and its functions. The students represented non-mathematics majors who were required to take a calculus course using a graphing calculator. Twenty-four students were enrolled during the summer semester. Eleven students participated in the study. Even though 24 students were registered, only 11 completed the post-survey. Four students were sophomores, four were juniors, and three were seniors. Six students were males, and five were females. Eight students were in the age range of 18-22, two in 23-30, and one in 31-40.

Instrumentation

The attitude instrument used for the survey has been used in a previous study with a reliability of .89 (Smith & Shotsberger, 1997) on students and their use and ability with graphing calculators in a college algebra course. That study measured attitude as well as student opinion about the college algebra course. The attitudinal survey, administered at the end of the course, consisted of 25 items to which students responded using a Likert Scale from *Strongly Disagree* (1) to *Strongly Agree* (5) about mathematics. The students also were asked to respond to a survey (see Appendix C) at the end of the course about their usage of graphing calculators and for which topics the tutorial was helpful in understanding the derivative and integration concepts better (Smith & Shotsberger, 1997). Students were asked to take a pre- and post-quiz (see Appendix D) on the functions of a graphing calculator; specifically derivative and integration functions.

Attitude Survey

Smith and Shotsberger (1997) used the survey to measure students' attitude about mathematics in their study on using graphing calculators in college algebra. The survey was piloted a semester prior to the study to optimize reliability and validity. The results indicated the surveys were valid and reliable enough for the study to proceed. The 25 items range from liking mathematics to learning new concepts in mathematics and the student's attitudes about themselves in mathematics. Some of the items gauge positive and negative attitudes towards mathematics such as "I am good at working mathematics problems" to "Material taught in math courses is not worth learning." The 25 statements were also separated into the categories of attitude towards mathematics, self-confidence in mathematics, appreciation of mathematics, and learning mathematics. By doing this, the researcher saw how students were affected by the different aspects in regards to mathematics. Seven items have been added by the researcher to the original survey in order to evaluate a student's graphing ability to use a calculator. The graphing calculator questions covered student ability to perform basic calculator functions to being able to program and graph. The graphing calculator questions are asked on a scale of 1 to 5 with *excellent* being 1 and *not able* being 5. The survey was administered at the end of the semester along with the post-quiz.

Pre-Quiz and Post-Quiz

The pre-quiz and post-quiz (see Appendix D) consisted of ten open-ended questions on graphing calculators, derivatives, and integration material that would be covered during the course. The pre-quiz was administered by the professor of the course and the post-quiz was administered by the researcher. Each quiz consists of the same five calculus (MAT 102) problems and the same five graphing calculator questions. Both quizzes have the same format and same problems that are taken from the textbook randomly by the researcher. The questions represent the types of problems about derivatives and integration that students learn about throughout the semester. The pre-quiz was conducted at the beginning of the semester and the post-quiz was conducted during the last week of classes. Both quizzes were graded and the scores compared.

End of Course Usage Survey

The students also completed a survey (see Appendix C) at the end of the course about the use of their graphing calculators and to identify topics the tutorial was helpful in understanding the mathematics concepts better (Smith & Shotsberger, 1997). This survey was modified by the researcher to reflect calculus content versus college algebra content. The original survey asked questions about college algebra concepts such as functions, logarithms, and graphing. The purpose of this was to find out from students how much they used their graphing calculator on their homework and when studying for tests.

Interview Protocol

The interview questions (see Appendix F) were developed in order to find out what the instructor thought about the tutorial and how he directed the students to use the tutorial. The interview was done in person by the researcher the semester following the completion of surveys by the students. The interview was digitally taped in order for the researcher to review the answers and summarize the thoughts of the instructor.

Observation Protocol

The researcher took field notes while in the classroom prior to the students taking the post-quiz and survey. The instructor was reviewing for the final exam and explaining to the students what to expect.

The Web Tutorial

The Web-based tutorial supports all levels of graphing calculator ability by starting with the basics, then going into further detail with trigonometry, graphing, linear regression, derivatives, and integration (see Appendix E). Students select a starting point where they feel most comfortable with the topics being covered and have the greatest confidence in their mathematical skills. The primary goal of the online tutorial for graphing calculators is to help college students become more proficient and confident in their ability to use a graphing calculator both inside and outside of class. Another goal is for the students to be able to move into a higher mathematics course in college. The target audience for this tutorial is college students who are non-mathematics majors taking mathematics courses that require the use of a graphing calculator. The tutorial highlights the main points of linear regression, graphing, trigonometry, derivatives, and integration.

The tutorial guides the students through the different functions of a graphing calculator including trigonometry, linear regressions, graphing, derivatives and integration. Different cognitive strategies are used throughout the tutorial including selective perception, rehearsal, semantic encoding, retrieval, and executive control (Rothwell & Kazanas, 2004). These five strategies were used to engage the student using the tutorial, to enhance the learning process, and to understand different functions of a graphing calculator.

With perception, the tutorial highlighted the various functions of a graphing calculator. The main page previewed different functions and what was to be expected. With each function, students saw possible choices for each of the functions by clicking on the button for the function. There were examples for each of the topics under the functions. This allowed the students to see different types of examples for each topic.

With rehearsal, the students saw graphics of the graphing calculator screens as they went through the tutorial with their own graphing calculators. This allowed the student to know if they were on the correct screen for the steps throughout the tutorial. The steps are given in short, precise wording in order for the student to follow along. Each function allows a student to focus on one topic at a time rather than having all the information at once. For semantic encoding, students use information about graphing calculators they previously learned in order to learn new concepts on the graphing calculator. The different functions within the tutorial breakdown the functions into topics which were easy to review and understand. As a student goes through the topics, the examples increased in difficulty. For retrieval, visual images of the graphing calculator screens were used in the tutorial in order for the students to know if they were completing the steps correctly on their graphing calculator. Lastly in executive control, students control the pace of the tutorial. They were able to go to different functions of the graphing calculator at their own speed. The buttons for the functions were on the side bar of each web page in order for students to go where they needed.

The different cognitive strategies allowed students to set the pace of the tutorial and review material when needed. Also, it helped students to better understand their graphing calculator functions.

Instructional strategies were used throughout the tutorial while students were learning about the different functions of their graphing calculator. The instructional strategies used include gaining attention, stimulating recall, presenting stimulus material, providing learning guidance, assessing performance, and enhancing retention and transfer

(Rothwell & Kazanas, 2004). The strategies were used to enhance the students' instruction throughout the tutorial.

Gaining attention of the students required the tutorial to be self-paced and student controlled. Throughout the tutorial, animation, example screens, and detailed instruction were used next to the steps for the different functions. This allowed the students to be alert for what they had on their graphing calculator. In stimulating recall, students had practice problems and hints to recall what steps were taken when completing a problem on their graphing calculator. For presenting stimulus material, the tutorial was learner-centered because it allowed students to work at their own paces. The tutorial allowed students to see what screen they had their calculator on and what the steps were for each screen. The screen shots were used throughout the tutorial for visual students who need the reinforcement to know they were going in the correct direction. In providing learning guidance, the student was provided with a glossary of terms and possible calculator errors that may occur. This allowed the student to know the meaning of terms if forgotten, and for student to know what the error messages meant. Assessing performance of students involved giving student access to quizzes which allowed them to check their graphing calculator proficiency with different types of functions. For enhancing retention and transfer, students were given real-world applications for certain graphing calculator functions and links to Web resources for other types of applications.

The tutorial consists of different levels of interactivity including reactive, coactive, and proactive. At the beginning of the tutorial, students can decide where to start with graphing calculator assistance. A student controls the pace of the tutorial based on previous knowledge and what he or she needs to learn more about. The different topics have general problems a student encounters as well as application problems from mathematics courses. The students make use of visual images of the graphing calculator screens as they go through the tutorial with their own calculator. This allows students to know if they are on the correct screen for the steps they are taking throughout the tutorial. The steps are given in short, precise wording in order for the student to follow along with little trouble in the examples. Also, students use information about graphing calculators they have previously learned in order to learn new functions on the graphing calculator. The information presented to the student is learner-centered because the student is solving mathematical problems as they are going through the tutorial at their own pace. The problems in the derivative and integration tutorial are similar to what the students are working for homework throughout the semester. A derivative and an integration application problem was given as an example for students to work through in order for them to better understand the applications with the calculus function.

Procedures

Data was collected from the students with paper and pencil based attitudinal survey and pre- and post-quizzes administered during class. Participants were asked in the first two class meetings to sign consent forms if they wished to participate in the study. Those who chose not to participate had the option of completing a different pre- and post-quiz that did not include questions about graphing calculators and its functions. Students were identified by a randomly assigned number on the surveys and quizzes.

The pre-quiz was given at the start of the second week of class to students who participated in the study. Students were given 30 to 45 minutes to finish the quiz. After taking the pre-quiz, the students were given the website address for the tutorial to access at their convenience. The post-quiz and attitudinal survey was given during the final week of classes at the end of the semester. Additionally, students completed an open-ended survey indicating the use of their graphing calculators as well as their thoughts on the tutorial. The researcher also interviewed the professor four months later to ask questions about how the students reacted to the quiz and what he thought about the tutorial and use of graphing calculator in the classroom (Appendix F). The interview was digitally taped and reviewed by the researcher in order to summarize what the instructor's answers were. The classroom observation was conducted on the day the students completed the survey and post-quiz. The researcher recorded field notes about what the students were doing in class as well as what the instructor was reviewing during the last class of the semester.

Data Analysis

The study used a case study multi-modal approach. The descriptive statistics reported on are race, sex, and age of the sample. Student responses to the attitude instrument and open-ended survey questions were analyzed for each student. The twenty five statements on the attitude instrument were separated into the categories of attitude towards mathematics, self-confidence in mathematics, appreciation of mathematics, and learning of mathematics. By doing this, the researcher saw how students were affected by different aspects in regards to mathematics. The results for the demographics of age, gender, and classification were complied and reported on overall and for each student.

The results for calculator usage while completing homework and studying for major tests were complied, and reported for each student and overall percentages. The graphing calculator questions were analyzed and reported on by ability to complete the task indicated. The tutorial usage were reported for each student and overall based on responses from students on the end of course survey. The interview with the instructor was summarized to highlight the need for more use of technology in the classroom. The observation filed notes were summarized to the teaching and learning required in the classroom.

Summary

The methodology for the study involved an attitudinal survey, a pre-/post-quiz and final course grade for the students, an interview with the instructor, and finally a classroom observation. By using a case study, the researcher collected the data with instruments that described the attitudes of students and how students performed on a quiz at the beginning of the course and at the end of the course. Using these methods to investigate the use of Web-based tutorials in assisting college students to learn mathematics skills, the researcher analyzed the data. The analysis of the data discussed in the next chapter answered the three research questions posed in Chapter I.

CHAPTER IV

ANALYSIS OF DATA

This research studied the effects of a graphing calculator tutorial for non-mathematics major students taking a required calculus course. This case study of eleven students and their professor in a summer business calculus course attempted to describe the changes in attitudes, achievement, and ability in using a graphing calculator with a post-survey, a pre-/post-quiz, and overall grade comparisons. In addition, the professor was interviewed following the course. After a brief review, students were given the post-quiz and provided adequate time to complete it. All students completed the post-quiz within 20 minutes. Most students attempted to solve the problems; two merely filled out the survey and left the quiz blank. Overall, the class did what was asked of them and completed the survey and quiz.

Descriptive Data

Even though 24 students were registered, only eleven completed the post-survey. Four students were sophomores, four were juniors, and three were seniors. Six students were males, and five were females. Eight students were in the age range of 18-22, two in 23-30, and one in 31-40. Based on the data collected from the eleven post-surveys, students actively used their graphing calculator 32.2% of their time while working on homework alone, and 47.5% of their time while taking a major test. While studying with others for a major test or working on homework, students reported using their calculator about 25.9% of the time and 17.9% for a major test. Only five of the students reported using the online tutorial: Students One, Eight, Nine, Ten, and Eleven. One comment made by a student about the use of calculators in the course was that calculators should be used in all mathematics courses. Students were also asked which topics the graphing calculator helped them understand better. Four students answered the question: two indicated derivatives and one each for applications and graphing derivatives. Four students indicated they did not use a graphing calculator due to cost.

The following questions were addressed using all the instruments:

1. Does the use of a tutorial for graphing calculators help students to better understand how to use the derivative and integration functions of a graphing calculator based on pre-quiz versus post-quiz scores?
2. Does the use of the tutorial change a student's attitude towards graphing calculators and mathematics as reflected on an attitudinal survey?
3. Does the use of the tutorial change a student's overall achievement in the course based on end of course grades?

Attitudinal Survey and Pre-/Post-Quiz

The twenty-five statements on the attitude instrument were separated into the categories of attitude towards mathematics, self-confidence in mathematics, appreciation of mathematics, and learning of mathematics. Due to the size of the summer class (n=24), the sample size was small with eleven students completing the post-survey. The results of the data allowed for the first two research questions posed to be answered for each of the eleven students in a descriptive format.

Student One, a junior, was a male between 23-30 years old. He answered no problems on the pre-quiz. His work on the post-quiz indicated that he did know how to perform integration, but did not use the correct intervals for arriving at the correct answer. Also, he did not know that rate of change indicated finding the derivative of a function. Based on his responses to the survey, Student One studied with other classmates about 50% of the time for tests and for completing homework. He used his calculator about 5% of the time while completing homework or taking a test in class and indicated that he used the graphing calculator tutorial for less than one hour. Because he did not use his calculator very often and used the tutorial less than an hour, he was not dependent on his calculator to do his work.

Student One stated that he was good at working mathematics problems, but was not looking forward to learning more mathematics. His attitude toward mathematics was neither positive nor negative, but he did not feel at ease in a mathematics classroom. Student One's self-confidence in mathematics was positive in that he was comfortable working mathematics word problems and did not get lost in the big picture. He appreciated what mathematics had to offer, but did not want to take another mathematics course unless necessary. In learning mathematics, Student One learned with the understanding that terms and formulas would make new ideas easier to understand. Overall, he thought that math was harder for him than most people but he achieved a C average in the course. As for his graphing calculator ability, he used his calculator for basic functions, graphing, and fractions, but had no idea how to input programs or change the windows for graphing.

Student Two, also a junior, was a male between 23-30 years old. He indicated that he used his calculator 90% of the time while working on homework and studying for tests, but did not use the tutorial. He worked on the homework and studied for tests about 50% of the time with others. His calculator usage began in high school algebra and continued in geometry, trigonometry, and college algebra. Based on this information, Student Two had used a graphing calculator for multiple classes and was at ease using it on a regular basis. He answered no problems on the pre-quiz. Based on his work in the post-quiz, Student Two understood integration and worked the problems correctly, but he did not know how to set up the application problems. He did not correctly find the derivative for the rate of change problem. However, he did know which menus to look under for the derivative and integration function on the graphing calculator.

Student Two had strong self-confidence in mathematics with an A average in the course and indicated he was proficient at working mathematics problems himself. He had a high appreciation for mathematics and understood that learning mathematics could help in learning other subjects. While learning mathematics, he realized that while there was a need for mathematics in jobs, the best jobs would not necessarily require any mathematics. As a result, he would not take another mathematics course unless required. As for his graphing calculator skills, he was able to perform basic operations, graph equations, and input fractions, but did not know how to input programs. He was competent in using the calculus function and changing the windows for graphs. He rated his ability to use the graphing calculator's different menus as poor.

Student Three, a junior, was a male between 31-40 years old. Based on his responses to the survey, Student Three indicated that he did not use the tutorial and had previously used a graphing calculator for an algebra class. He used his calculator about

12% of the time while doing homework and 4% when studying for a test. He studied with other students 20 to 30% of the time for homework and test. He answered no problems on the pre-quiz. On his post-quiz, Student Three answered the area between the curve question correctly, but did not do well on the application problems. He indicated that he did not know how to answer the calculator questions. His lack of knowledge ranged from a lack of ability to program a calculator to a lack of awareness of how to use the different menus. However, he demonstrated a very high degree of proficiency on basic functions and inputting fractions. He was comfortable with graphing equations and changing windows for the graphs, but his proficiency with the calculus functions was poor.

Student Three was confident in his ability to solve word problems and had good feelings toward mathematics. However, he would only take another mathematics course if required. In learning mathematics, he did learn terms and formulas by understanding them and did feel good when solving problems himself. Student Three's appreciation for mathematics was strong, and he disagreed with the statements that little mathematics was needed for most jobs, while the best jobs did not require any mathematics. Overall, Student Three agreed that material in mathematics courses was worth learning and noted that with an A average in the course, math was not hard for him at all.

Student Four, a senior, was a female between 18-22 years. Based on her responses to the survey, Student Four used her calculator 90 to 100% of the time while working on homework and studying for test, but did not use the tutorial. She spent 60 to 80% percent of her time studying with classmates when working on homework or studying for a test. She answered no problems on the pre-quiz. On her post-quiz, Student Four did find the derivative correctly on one problem, but miscalculated an exponent, resulting in an incorrect answer. This indicated that she knew what finding the rate of change meant in the application problem. For the other business problems, she did not understand the terminology. On the integration problems, Student Four did not show enough work to indicate the correct process required by the problems. She correctly answered two out of five of the calculator questions asking where the functions were located. Student Four's ranking of her calculator ability indicated that performing the basic operations, inputting fractions, and using the calculus functions were easy for her. Graphing equations, inputting programs, and using different menus on the calculator were almost as easy for her, with changing windows for graphing being slightly more difficult.

Student Four had some self-confidence when solving mathematics problems herself, but was not at ease in a mathematics classroom. She had little appreciation for what mathematics allowed her to learn in class or outside of class. In learning mathematics, she did not understand terms and formulas, performing by rote memorization. Her general attitude about mathematics was negative and she indicated that she would not take another mathematics course unless required. Overall, Student Four had a good grasp on how to use her calculator and a C average in the course, but did not see the importance of mathematics outside the classroom setting.

Student Five, a senior, was a male between 18-22 years old. He indicated on his survey that he did not buy a graphing calculator because he could not afford one. But, likely he did use a scientific calculator for class because he indicated on the survey that he used a calculator while studying for a test or completing homework 76 to 80% of the time. He studied with other students 5 to 9% of the time. Student Five did not answer any of the questions on the pre- or post-quiz. He indicated an excellent ability to perform basic operations on a graphing calculator, and poor ability on other calculator processes.

Student Five's indicated low levels of self-confidence. He did not look forward to learning more about mathematics, but agreed that most college students should study some mathematics. He also agreed that mathematics was not needed in most jobs and that the best ones required little or no mathematics. In learning mathematics, Student Five did not like math and worked hard at understanding the material he had to learn. His general attitude towards mathematics was negative and he would not take another mathematics course unless required. Overall, Student Five worked hard to complete the course with a C average and struggled to understand mathematics.

Student Six, a sophomore, was a female between 18-22 years old. She did not answer any questions on the pre- or post-quiz. Based on her responses to the survey, she spent about one to two hours each week studying or doing homework with others and also spent the same amount of time using her calculator, but did not use the tutorial. Student Six showed moderate proficiency in her ability to use her graphing calculator. She did not know how to use the calculus functions on her calculator and had a poor idea of how to input programs or use the different menus. However, she demonstrated good ability when graphing equations and changing windows for them as well as an excellent ability to perform basic operations and input fractions.

Student Six showed little confidence in her attitude towards being able to solve mathematical word problems. Her learning ability in mathematics was hampered by rote memorization of terms and formulas without understanding the context in which to use them. In appreciating mathematics, her general attitude towards mathematics was negative in that she did not feel at ease in a mathematics classroom and would not take another math course unless required. However, Student Six thought college students should study mathematics. Overall, Student Six demonstrated proficiency with mathematics with an average of an A in the course, but struggled with mathematics learning.

Student Seven, a sophomore, was a female between 18-22 years old. She did not answer any questions on either the pre- or post-quiz. Based on her responses to the survey, she reported using her calculator about 50% of the time while she worked on homework and studied for test. An independent learner, she studied with others ten percent of her time while she worked on her homework and had an overall good ability to use her graphing calculator, but did not use the tutorial.

Student Seven's degree of self-confidence towards mathematics was not high and she thought mathematics was harder for her than most people. Her appreciation for mathematics was more positive than negative and she thought the material was worth learning. However she would not take another mathematics course unless required and would preferred to have a job that did not require a lot of mathematics. In learning mathematics, Student Seven learned terms and formulas to understand concepts. Overall, Student Seven's attitude towards mathematics was more positive than negative, but she occasionally struggled with learning the material with an average of a B in the course.

Student Eight, a senior, was a female between 18-22 years old. She did not answer any questions on the pre-quiz and tried to answer the area between the curves question on the post-quiz but did not complete the problem. Based on her responses to the survey, Student Eight spent 100% of her time using a calculator on homework and studying for tests. She studied with other students for tests 50% of the time and spent 75% of her time working on homework with others. She spent less than an hour on the tutorial and had used a graphing calculator in high school mathematics courses and in college algebra. Student Eight knew how to perform basic operations on a graphing, but did not know how to use the calculus functions on a graphing calculator.

Student Eight's general attitude towards mathematics was negative. She did not look forward to learning more about mathematics and was not at ease in a mathematics classroom. She had neither a positive nor negative attitude about learning mathematics. Student Eight's appreciation for mathematics was very negative with thoughts that mathematics was not worth learning and it did not help in learning other subjects. She had negative self-confidence in her ability to solve problems and thought math was harder for her than most people. Overall, Student Eight did not enjoy mathematics, yet managed a B average in the course.

Student Nine, a sophomore, was a male between 18-22 years old. He did not answer any questions on the pre-test. On the post-test he answered the two questions about which menu contained the derivative and integration functions. He also found the correct integration for the area of the shaded region, but did not appropriately apply a definite integral to the integration. Based on his responses to the survey, Student Nine spent less than one hour on the tutorial and used a graphing calculator in high school algebra and trigonometry. He used his calculator about 60% of the time while studying for a major test. He did not study with anyone during the semester. Student Nine knew how to perform the basic operations on the graphing calculator, and had good ability on graphing, window changes, and use of the calculus functions.

Student Nine's general attitude towards mathematics were neither positive nor negative and was neutral on taking another mathematics course. His appreciation for mathematics was slightly more positive in that he did have a good feeling toward mathematics. In learning mathematics, Student Nine agreed that learning formulas and technical words, and the use of charts, graphs, and tables were important in mathematics. His self-confidence in mathematics was positive, with a good feeling about solving mathematics problems and word problems. Overall, Student Nine had a slight positive attitude towards mathematics and an overall course grade of C for the semester.

Student Ten, a sophomore, was a female between 18-22 years old. She answered no questions on the pre-quiz and indicated on the post-quiz that she did not have a graphing calculator. She tried to answer two of the application problems, but did not find the derivatives appropriately. Student Ten used the tutorial for less than an hour and used a scientific calculator about twelve percent of the time to study for a test. She studied with no other classmates during the semester.

Student Ten's general attitude towards mathematics was positive in that she would take another mathematics class and looked forward to learning more about mathematics. Her appreciation for mathematics was positive in that she agreed that college students should study some mathematics, and she had good feelings towards mathematics. In learning mathematics, Student Nine learned technical terms and formulas with understanding. Her self-confidence in mathematics was both positive and negative. On the positive side, she felt good when solving a problem on her own and thought mathematics was easier for her than most people. Her experience was negative in the sense that she was lost in the big picture of concepts and often thought she could not work a mathematics problem when it was hard. Overall, Student Ten had a positive attitude towards mathematics, but only achieved a D average for the course.

Student Eleven, a junior, was a male between 18-22 years old. He answered no questions on the pre-quiz and on the post-quiz; he set up the shaded area problem correctly, but did not finish the problem. Based on his responses to the survey, he used a calculator 20% of the time while doing homework studying for tests. He spent 10% of his time studying with others for test and completing homework. Student Eleven spent less than one hour on the tutorial and had used a graphing calculator in high school mathematics courses. He was able to perform the basic operations and inputting fractions into the calculator well. Student Eleven showed moderate proficiency graphing equations, changing windows and using the calculus functions.

Student Eleven's general attitude towards mathematics was negative in that he did not look forward to learning more about mathematics and would only take another mathematics course if required. In learning mathematics, he learned technical terms and formulas without understanding and knew that charts, graphs, and tables were important in mathematics. His appreciation for mathematics was negative as he did not have good feeling towards mathematics and thought that there was little need for mathematics in most jobs. His self-confidence level was negative as well. He was not proficient at working mathematics problems and felt little confidence in solving mathematics word problems. Overall, Student Eleven was not confident in his ability to succeed in mathematics and achieved a C average in the course.

The students were split in their attitudes toward mathematics. Some had positive and others had negative attitudes. Overall, the students were not going to take another mathematics course unless required, but most understood the importance of mathematics in the workplace.

Overall Course Grade

With respect to the last study question, "Does the use of the tutorial change students' overall achievement in the course based on end of course grades?", analysis of student grades indicated ten of the eleven students passed with a C or better and one of the students received a D or F. Six of the students used the tutorial less than an hour during the semester and all passed the course. Therefore, there was insufficient evidence to determine whether the tutorial helped the students change their overall achievement in the course. Overall, students had small changes in their attitudes towards mathematics.

Interview

The interview with Dr. Black, a pseudonym, was conducted on November 22, 2011 in his office. Dr. Black had the students complete the pre-quiz during the first week of class. The students did not ask any questions while taking the quiz, even in cases where none of the problems were attempted, as they had not yet been exposed to the material. Dr. Black did not make any comments about the tutorial to the students and the students did not ask any questions about it. He did not mention the tutorial after the pre-quiz was taken other than to hand out the Web address on the consent form. Dr. Black did not use a graphing calculator in his class because many students did not use them. Some students did use them on a regular basis, but mainly for simple computations. Dr. Black expressed concern with the quality of algebra skills of the students in the brief applied calculus course. He observed that the level of algebra skills was declining over time and this was a concern among the mathematics faculty. Clearly, students were not encouraged to use the tutorial by the professor.

In summary, these students were not dependent on their graphing calculators to learn calculus, but did use the graphing calculators for the basic operations and graphing functions. These students were not inclined to take additional mathematics courses unless required and would prefer jobs that did not require much mathematics. As indicated by the pre-quiz for the course, students had not been exposed to the material prior to the course.

Summary

The analysis of the data concluded that the students did not use the tutorial often. Therefore, there was no way to effectively say if the tutorial made a difference in the overall course grade for the five students who accessed the tutorial given they accessed it for less than one hour. The students' attitudes overall were neither positive nor negative. Students usage of their graphing calculator showed that the students were not dependent on them in order to learn the material taught in the course. Overall, students were not going to take another mathematics course unless required, but most understood the importance of mathematics in the workplace. There was insufficient evidence to determine whether the tutorial helped the students changed their overall achievement in the course. The instructor for the course did not encourage the students to use the tutorial. Therefore, he was not using graphing calculators in the course to help students learn the material. In conclusion, students were not dependent on their graphing calculator to understand the material. In the next chapter conclusions were drawn based on the data analysis and future research discussed.

CHAPTER V

DISCUSSION

Students taking a calculus course who are not mathematics majors do not often use a graphing calculator when working on derivatives or integration. Students' attitudes towards mathematics changed little over the course of the semester. This study was limited by not having access to all three of the courses taught during the summer semester. Due to having only one group of students complete the surveys, comparison to another group was not possible. One comment made by a student about the use of calculators for the course was that calculators should be used in any mathematics class. Four students indicated they did not use a graphing calculator due to cost. Only five students accessed the tutorial and used it for less than one hour each. This indicated that students did not have an interest in using the tutorial and were not dependent on their graphing calculators to understand the mathematics behind the calculus and application problems.

By using a case study, the researcher collected the data with instruments that described the attitudes of students and how students performed on a quiz at the beginning of the course and at the end of the course. Using these methods to investigate the use of Web-based tutorials in assisting college students to learn mathematics skills, the researcher analyzed the data. The analysis of the data concluded that the students did not use the tutorial often. Therefore, there was no way to effectively say if the tutorial made a difference in the overall course grade for the five students who accessed the tutorial given they accessed it for less than one hour. The students' attitudes overall were neither positive nor negative. Students usage of their graphing calculator showed that the students were not dependent on them in order to learn the material taught in the course. Overall, students were not going to take another mathematics course unless required, but most understood the importance of mathematics in the workplace. The instructor for the course did not encourage the students to use the tutorial. Therefore, he was not using graphing calculators in the course to help students learn the material. In conclusion, students were not dependent on their graphing calculator to understand the material.

The research questions were answered with the results from the attitudinal survey, pre-/post-quiz, and the end of course grade. Based on the results, students' attitudes changed little overall. An interesting find for three students was their attitudes were opposite of their overall grade for course. For example, Student Six showed little confidence in learning mathematics and did not feel at ease in a mathematics classroom. Yet, she managed to earn an A in the course. Student Eight had similar results. She did not think mathematics was worth learning and thought mathematics was difficult for her. Her overall grade for the course was a B which indicated she worked for here grade and tried her best. The last student, Student Ten, had a positive attitude towards mathematics, but only achieved a D average for the course. These results showed that a student's attitude did not necessarily translate into a grade which reflected their positive or negative attitude towards mathematics.

The results neither confirmed nor contradict the current literature. The study should be conducted again using a larger sample size to determine consistency with current literature indicating that calculators, when used appropriately, help students to better understand the mathematics. Due to communication issues, this study was conducted during the summer semester. The 24 students enrolled may or may not have been representative of the students who take the course during the academic year. Approximately 300 students take this course during the fall and spring semesters in sections capped at 75 and taught by two different instructors. In addition, of the 24 students enrolled, data from only 11 could be used.

In addition, this study would have been strengthened by interviewing those students who had used the tutorial. Mathematics is not always a favored subject. Attitudes vary with students depending on the situation within the mathematics course or concept being taught. Web-based tutorials or instruction helps to change the attitudes of students towards mathematics (Pierce, Stacey, & Barkatas, 2007; Ruffell, Mason, & Allen, 1998; Townsend & Wilson, 2003; Yusef & Tall, 1999). With the introduction of technology into the curriculum across grade levels, students are having a more enjoyable time learning mathematics. Technology infusion has led to Web-based mathematics as well as online tutorials not just for mathematics, but other subjects as well. The Math Emporium (Moore, 2001) at Virginia Tech has grown to include seven freshman level courses which are taught through web-based mathematics text, online quizzes and exams, instructor weekly help sessions as well as instructional assistants available at the emporium. Students who are successful in their courses have to learn time management as well as when to ask for help.

With students coming into college with a good background in using a graphing calculator, instructors could exploit the background knowledge to have students better understand the calculus concepts being taught in an applications setting. Knowing how to graph functions on a graphing calculator would help in understanding integration and the concept of area under a curve. By graphing the function, a student can easily see what the endpoints are and what function needs to be subtracted from the other. By allowing students to use the graphing calculators in a course, an instructor focuses more on the applications needing to be taught, especially in a business calculus course. Dr. Black made a good point in that students struggle with basic algebra. One thing that may contribute to this is that many students do not take a basic mathematics course until the second or third year of college. In many cases, basic algebra skills may have atrophied for lack of use.

The researcher herself teaches online courses for a major university and the students in the online courses have access to the tutorial through the Webliography in the online classroom course material. As to whether or not the students are using the tutorial, the researcher had no way of knowing how much the students were using the tutorial without questioning them each semester. There are plans to expand the existing tutorial used in this study to include information on matrix and statistical function in the near future. These topics were being expanded due to the courses the researcher taught on a regular basis and the concepts taught in the courses. Also, the researcher was changing the format to include more examples and less quizzes questions due to students normally wanting lots of examples of problems they encounter versus quiz format.

Future research would focus on the use of graphing calculators in freshman level college courses and how instructors are allowing students to use technology. This research could be approached using a quantitative or qualitative study with questionnaires or surveys to the instructors as well as the students as to how the technology is being used and what is effective for the courses. Questions that arose from the research include:

- How do college or university mathematics departments allow the use of graphing calculators in the courses taught at any level?
- Are pre-service teachers being exposed to the appropriate use of graphing calculators in the classroom?
- How can students better understand mathematics with the use of calculators?
- Do other departments allow the use of graphing calculators in their courses at any level?

Summary

Research in mathematics education has been ongoing for many years. Technology has made an impact on mathematics education allowing for advancement in the teaching of mathematics. Teaching with technology has allowed for advancements in student learning and has allowed teachers to delve deeper into some mathematics topics. Online tutorials have helped students to better understand concepts in courses including mathematics by allowing for review of material at the student's own pace. Online tutorials allow students to review class material before an exam or quiz, and may contribute to enhanced success of students who make use of the tutorials.

The data from the study showed that students were not necessarily dependent on their graphing calculators in order to understand calculus. The attitudes of students towards mathematic was neutral overall, yet some may go to one extreme or the other. Students agreed that mathematics is important in the workplace and would only take another course if required too. This research showed that technology is important, but was not a driving force in students' learning in the course.

APPENDIX A

IRB APPROVAL FORM

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board

118 College Drive #5147
Hattiesburg, MS 39406-0001
Tel: 601.266.6820
Fax: 601.266.5509
www.usm.edu/irb

HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE
NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee 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: **29102901**
PROJECT TITLE: **Does the Use of a Graphing Calculator Tutorial Affect the Attitudes, Achievement, and Calculator Ability of Non-Mathematics Majors in a Calculus Course?**
PROPOSED PROJECT DATES: **01/19/10 to 08/11/10**
PROJECT TYPE: **Dissertation or Thesis**
PRINCIPAL INVESTIGATORS: **Kari Everett**
COLLEGE/DIVISION: **College of Science & Technology**
DEPARTMENT: **Science and Mathematics Education**
FUNDING AGENCY: **N/A**
HSPRC COMMITTEE ACTION: **Expedited Review Approval**
PERIOD OF APPROVAL: **12/07/09 to 12/06/10**

Lawrence A. Hosman
Lawrence A. Hosman, Ph.D.
HSPRC Chair

12-9-09
Date

APPENDIX B

E-MAIL TO COURSE INSTRUCTOR

Date: August 15, 2009
To: Instructor of MAT 102: Brief Applied Calculus
From: Kari Everett, researcher

To whom it may concern:

I am asking your permission to obtain a copy of the final exam scores, student rosters before and after the drop date of the class and a copy of the syllabus given to the students at the beginning of the semester Summer 2010. Thank you for your cooperation in my research project.

Sincerely yours,

Kari M. Everett
Center for Science and Mathematics Education

APPENDIX C

END OF COURSE CALCULATOR USAGE SURVEY

Previous to this course, have you ever used a graphing calculator in other courses (high school or college)?
If so, please explain where, and for what courses.

The following questions pertain to the instruction in calculus which took place during the semester. Respond thoughtfully to the following questions.

1. Approximate the amount of time you spent each week using the tutorial while working on your mathematics homework assignments. What percentage of this time were you…
   a. Actively using your calculator?
   b. Studying with others rather than alone?
2. Approximate the amount of time you spent studying for a major test. What percentage of this time were you…
   a. Actively using your calculator?
   b. Studying with others rather than alone?
3. Approximate the amount of time you spent using the graphing calculator tutorial online?
   a. Less than 1 hr
   b. 1 – 2 hrs
   c. 2 – 4 hrs
   d. 4 – 6 hrs
   e. 6 or more hrs
4. A list of major topics covered in Math 102 is provided below. For which topics was your understanding most helped by the use of graphing calculators? (circle them) Give an example of how the tutorial was helpful.
   a. Derivatives
   b. Integration
   c. Applications
   d. Graphing derivatives

Please include here any other comments, ideas, or assessments you might have about the use of the calculator for this course. Remember to consider how your instructor used the calculator and how you used it.
Circle the one that applies to you.

5. Classification: Fr So Jr Sr
6. Male Female
7. Age: 18-22 23-30 31-40 41-50 50 +

APPENDIX D

PRE-QUIZ AND POST-QUIZ

Answer the following questions to the best of your ability. Make sure you follow all directions.

Name___________________________________ MAT 102 Pre/Post-Test

Solve the problem.

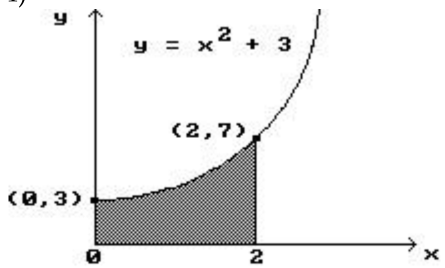
1) The sales in thousands of a new type of product are given by $s(t) = 60 - 50e^{-0.2t}$, where t represents time in years. Find the rate of change of sales at the time when t = 3.

2) A bookstore has an annual demand for 34,000 copies of a best-selling book. It costs $. 30 to store one copy for one year, and it costs $110 to place an order. Find the optimum number of copies per order.

3) Find the producers' surplus if the supply function of some item is given by $S(q) = q^2 + 2q + 8$. Assume supply and demand are in equilibrium at q = 30.

Find the area of the shaded region

4)



Find the area between the curves.

5) $y = 2x - x^2$, $y = 2x - 4$

Answer the following questions.

6) Under what menu is the derivative function on your graphing calculator located?

7) What are the steps to find a derivative of a graph at a certain point?

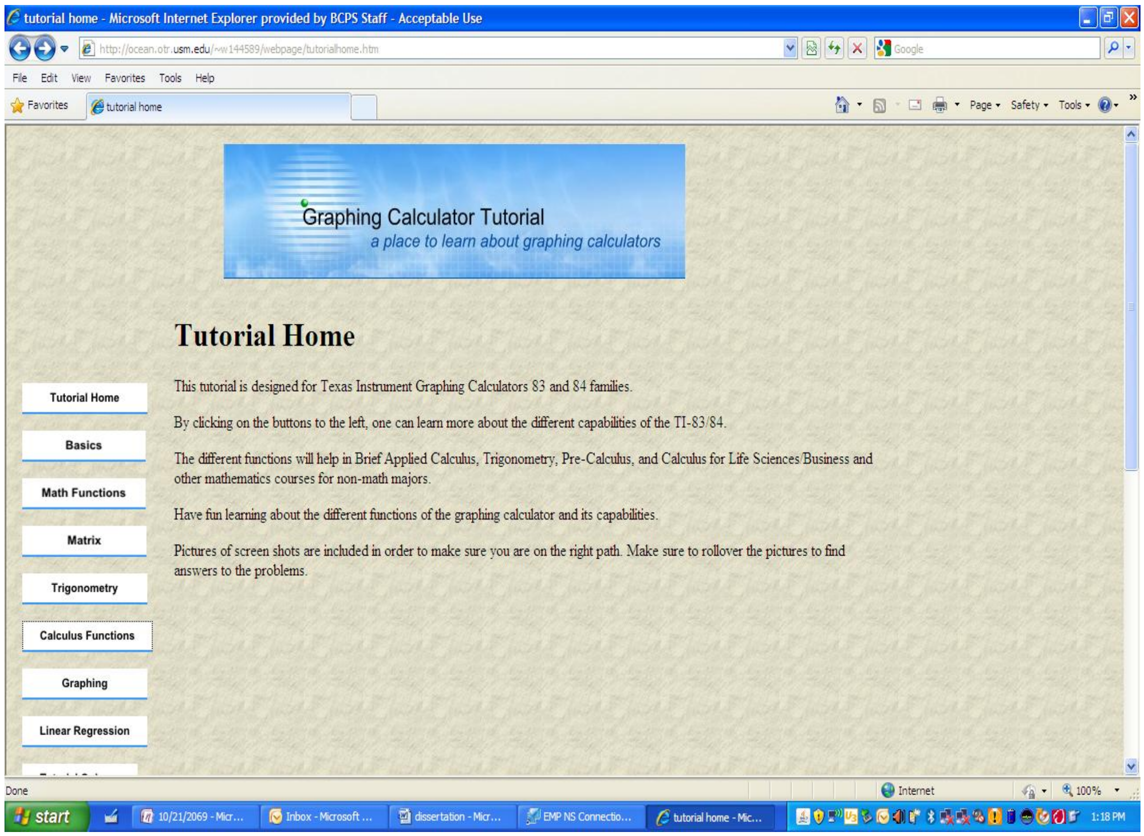
8) Under what menu is the integration function on your graphing calculator located?

9) What are the steps to find the definite integral of a function on your graphing calculator?

10) What do you need to type into your calculator after "*fnInt(* " to find the definite integral of a function?

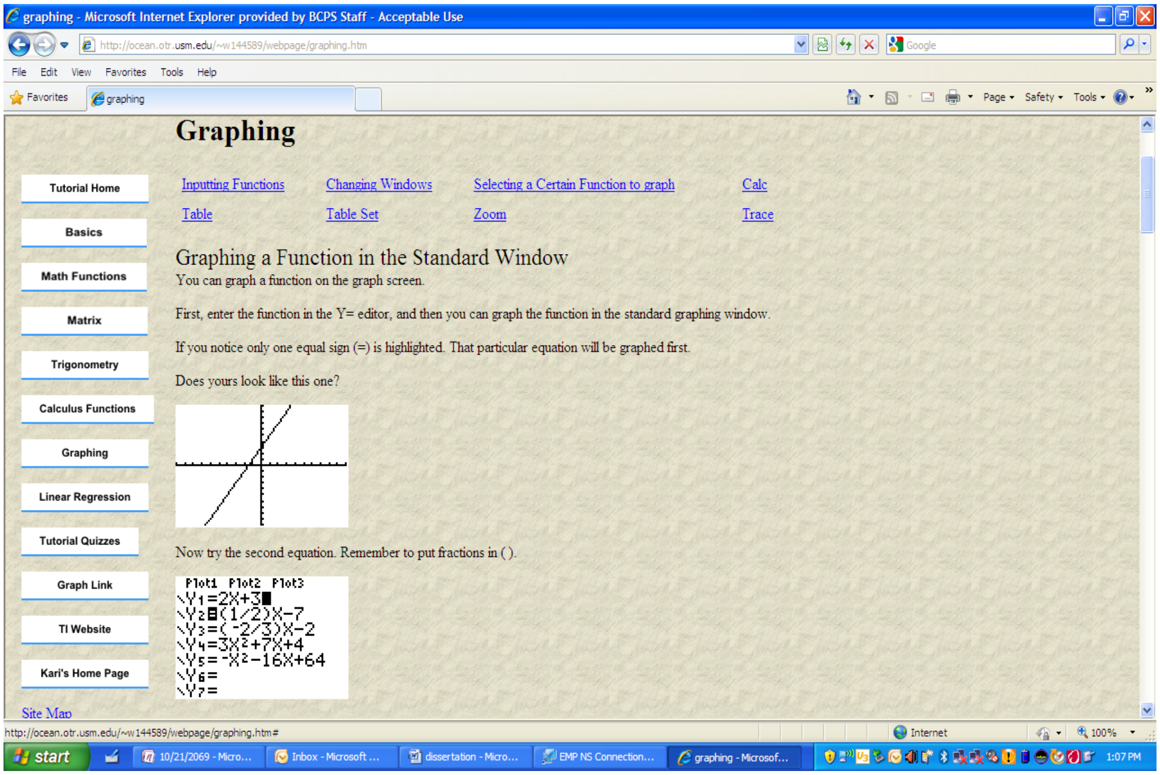
APPENDIX E

TUTORIAL SCREEN SHOTS



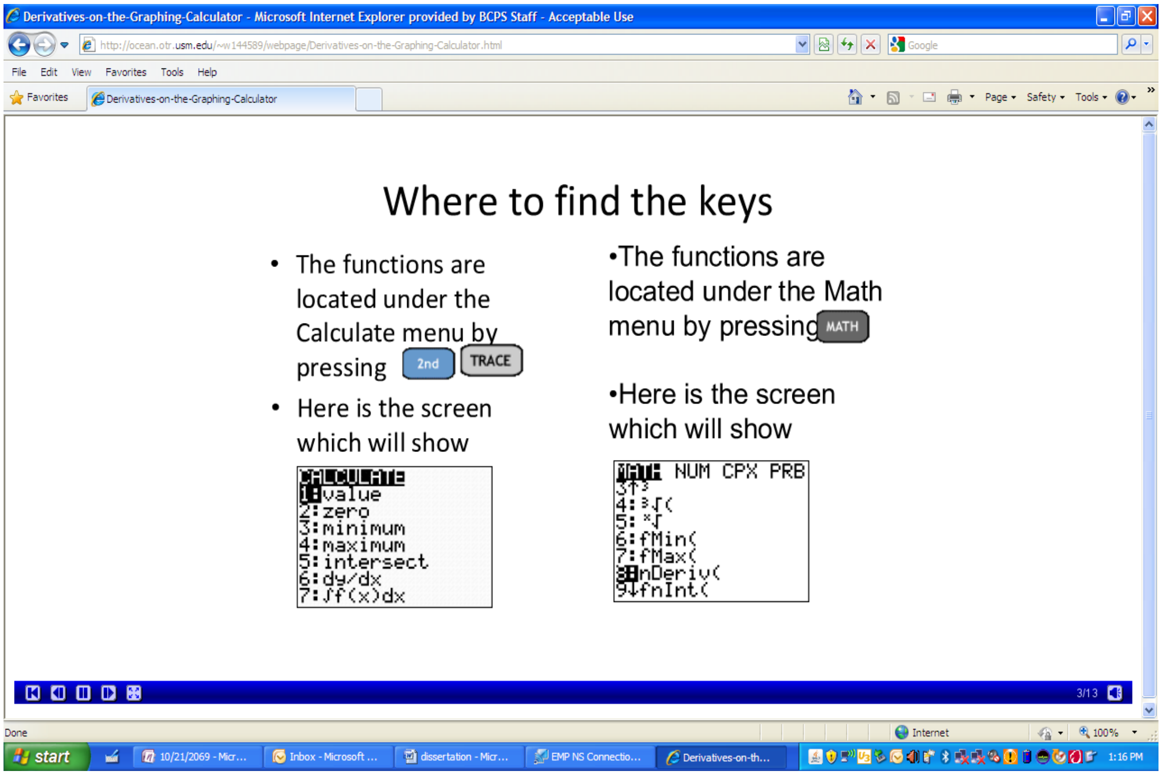
The homepage for the tutorial

Start of the page on graphing equations

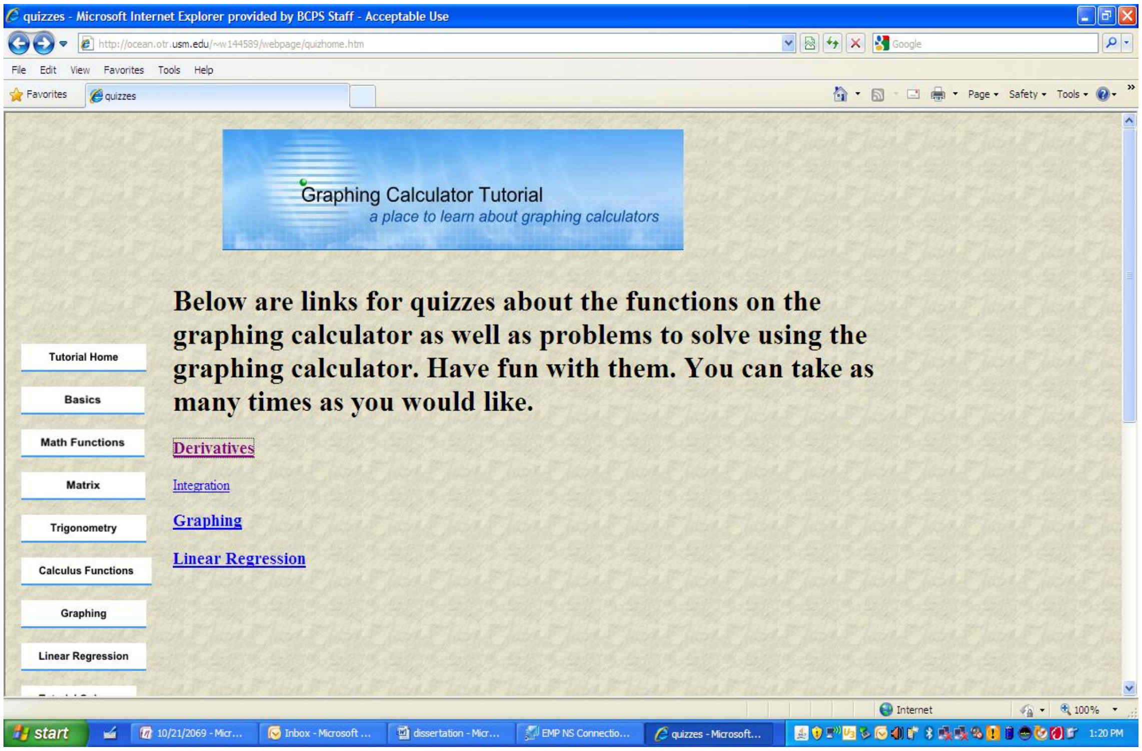


The first screen shot has been rolled over to show the correct graph.

This page takes you through power point slides for derivatives and integration



This shot is at the beginning of the power point for derivates showing where to find the functions for derivatives on the calculator.



The quiz link page.

APPENDIX F

INTERVIEW QUESTIONS WITH PROFESSOR

1. When did you administer the quiz to students?
2. What type of questions did students ask about the quiz/survey?
3. What were the general attitudes of the students when taking the test?
4. What comments, if any, did you make to students about the tutorial?
5. What were students comments about the tutorial?
6. How did you reinforce student use of the tutorial? Did you mention the tutorial after the initial introduction?
7. What motivation did the students have to use the tutorial?
8. How do you think the tutorial would benefit students?
9. Positive/negative comments about the tutorial?
10. At any point during the course, did you use a graphing calculator to show students how to work a problem for class? If so, what type of problem did you use it for and why?
11. If graphing calculators were more accessible for students, how would you incorporate it into your class?

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