THE EFFECT OF GRAPHING CALCULATORS IN
ALGEBRA II CLASSROOMS: A STUDY
COMPARING ACHIEVEMENT,
ATTITUDE, AND
CONFIDENCE

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Beverly Scott, B.A., M.E.T.
Denton, Texas
August, 1994
THE EFFECT OF GRAPHING CALCULATORS IN
ALGEBRA II CLASSROOMS: A STUDY
COMPARING ACHIEVEMENT,
ATTITUDE, AND
CONFIDENCE

DISSERTATION

Presented to the Graduate Council of the
University of North Texas in Partial
Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

By

Beverly Scott, B.A., M.E.T.
Denton, Texas
August, 1994

The purpose of this study was to investigate the effectiveness of the graphing calculator on the achievement, attitude toward mathematics, and confidence in learning mathematics of Algebra II students.

Completing the study were 86 Algebra II students and three teachers in the experimental group and 84 Algebra II students and three teachers in the control group. Each teacher taught both experimental groups and control groups and was provided staff development prior to the beginning of the treatment. Each of the teachers used the graphing calculators in the experimental groups to teach the conic sections unit which encompassed approximately six weeks of instruction.

Prior to the treatment, students in both the experimental and control groups were given the pre-test Form A of the Purdue Master Attitude Scale and the pre-test Fennema-Sherman Confidence in Learning Mathematics Scale. Further, the researcher examined the students’ cumulative
files and used the TAAS mathematic scores as the covariate for achievement.

Following the treatment, the post-tests completed by the students were the Test of Graphing Skills, Form B of the Purdue Master Attitude Scale, and Fennema-Sherman's Confidence in Learning Mathematics Scale. Achievement, attitude, and confidence measures were analyzed using an Analysis of Covariance (ANCOVA). The TAAS mathematics score was the covariate for achievement with the Test of Graphing Skills as the dependent variable. On the remaining two variables, attitude toward mathematics and confidence in learning mathematics, the pre-tests were utilized as the covariates, and the post-tests were the dependent variables. No significant difference was found on achievement; however, highly significant differences \((p < .0001)\) were found between the experimental and control groups in attitude and confidence in learning mathematics.

Recommendations for further research include expanding the study to encompass the entire school year, exploring the impact of graphing calculators on low achieving students, and exploring gender differences in mathematics as they relate to the graphing calculator.
## CONTENTS

**LIST OF TABLES** ................................................................. v  

**Chapter**

1. **INTRODUCTION**.............................................................. 1  
   Need for the Study  
   Statement of the Problem  
   Hypotheses  
   Definition of Terms  

2. **REVIEW OF THE RELATED LITERATURE**......................... 8  
   Introduction  
   Teaching of Mathematics with the Graphing Calculator  
   Utilization of Graphing Calculators to Address the NCTM Standards  
   Attitude Research in Mathematics  
   Confidence Research in Mathematics  
   Summary  

3. **METHODOLOGY**............................................................. 41  
   Introduction  
   Population  
   Instrumentation  
   Research Design  
   Data Analysis  

4. **PRESENTATION AND ANALYSIS OF DATA**......................... 51  
   Introduction  
   Pretreatment Analyses  
   Achievement Data Analysis  
   Attitude Toward Mathematics Data Analysis  
   Confidence in Learning Mathematics Data Analysis  
   Posttreatment Analyses  

5. **SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS** 60  
   Summary of Findings
Conclusions
Implications
Recommendations for Further Research

APPENDIX 1: CONSENT FORMS ......................... 70

APPENDIX 2: TEXAS EDUCATION AGENCY’S ESSENTIAL
             ELEMENTS FOR ALGEBRA II ............. 74

APPENDIX 3: TEST OF GRAPHING SKILLS
             PURDUE MASTER ATTITUDE SCALE
             CONFIDENCE IN LEARNING
             MATHEMATICS SCALE ..................... 80

APPENDIX 4: CONIC SECTIONS LESSON PLANS .......... 86

REFERENCES ............................................ 96
<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Comparison of Populations Utilizing TAAS Scores</td>
<td>42</td>
</tr>
<tr>
<td>2. Comparison of the Pretreatment TAAS Mathematics Scores of the Two Student Groups</td>
<td>53</td>
</tr>
<tr>
<td>3. Comparison of the Pretreatment Attitude Toward Mathematics Scores of the Two Student Groups</td>
<td>54</td>
</tr>
<tr>
<td>4. Comparison of the Pretreatment Confidence in Learning Mathematics Scores of the Two Student Groups</td>
<td>55</td>
</tr>
<tr>
<td>5. Comparison of the Posttreatment Graphing Skills Test Scores of the Two Student Groups with the TAAS Mathematics Scores as the Covariate</td>
<td>57</td>
</tr>
<tr>
<td>6. Comparison of the Posttreatment Attitude Towards Mathematics Scores with the Pretreatment Scores as the Covariate</td>
<td>58</td>
</tr>
<tr>
<td>7. Comparison of the Posttreatment Confidence in Learning Mathematics Scores with the Pretreatment Scores as the Covariate</td>
<td>59</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

Need for the Study

Achievement in mathematics has been one of the debates in educational reform in the past decade. Numerous reports (McKnight, et. al., 1987; Dossey, et. al., 1988) speak of serious deficiencies in the mathematical performance of students in the United States. The concern began in 1983 with the publication of A Nation at Risk which led to an outcry for change. Since its publication more than 300 reports have urged change in mathematics education (Robin & Fraser, 1991). The underlying need for change in the mathematics curriculum was the shift in the United States from an industrial to an information-based society (Romberg, 1992). Thus, the purpose of this study was to examine the effect of the utilization of the graphing calculator on the achievement, attitude toward mathematics, and confidence in learning mathematics of Algebra II students.

This report was followed by the Second International Mathematics Study (SIMS) in 1984 which showed the United States was improving somewhat in the teaching and learning of lower-level skills, but not making much progress with higher level skills while Japan made their most dramatic improvements with the higher level skills (1987). This led
to a rethinking of the mathematics curriculum because, as stated by the National Research Council in *Everybody Counts: A Report to the Nation on the Future of Mathematics Education*, "current mathematical achievement of United States students is nowhere near what is required to sustain our nation's leadership in a global technological society, and to participate fully in the world of the future, America must tap the power of mathematics" (1989, p.1).

The rethinking of the mathematics curriculum led researchers to investigate fully how learning can best be facilitated. As Dewey advocated, learning experiences are best facilitated when the learner is allowed to interact with the environment, and as a result of this interaction create their own meaning (Glatthorn, 1987). Further, according to Dewey the "primary root of all educative activity lay in the instinctive, impulsive attitudes and activities of the child" (1931, pg. 8). The National Council of Teachers of Mathematics (NCTM) also promoted this constructivist view of mathematics. Constructivism is concerned with learning theory and finds its roots in Piaget's stage development theories (Lerman, 1989). In other words, knowledge was seen as constructive, where learning occurs through active participation with the teacher as the guide through the process (Romberg, 1992). Thus, learners are free to construct their own meaning by connecting new information to what they already know,
building hierarchies of understanding (Standards, 1991).

Further, as delineated in the National Research Council's report Everybody Counts: A Report to the Nation on the Future of Mathematics Education, research in learning shows that students learn mathematics well only when they are allowed to construct their own mathematical understanding (1989). This is best summarized by the NCTM standards (1989) as follows:

The 9-12 standards call for a shift in emphasis from a curriculum dominated by memorization of isolated facts and procedures and by proficiency with paper-and-pencil skills to one that emphasizes conceptual understandings, multiple representations and connections, mathematical modeling, and mathematical problem solving. The integration of ideas from algebra and geometry is particularly strong, with graphical representation playing a connecting role. Thus, frequent reference to graphing utilities will be found throughout these standards (1989, p.124).

The changing face of mathematics curriculum and instruction leads to the conclusion that mathematics can no longer be performed as a "cookbook" method where students follow and emulate the performance of another. According to Piaget (1978) each individual constructs their own reality; concepts cannot be effectively learned through verbal methods alone (Wadsworth). Further, logical mathematical
knowledge can only develop if the child acts on objects (Piaget, 1970). The students must construct their own understanding and thus improve achievement. One may say these are very lofty goals but how can they be accomplished? Technology is a powerful tool which students can utilize to explore, to hypothesize, and to predict - in other words, to construct their own meaning. There has been a dramatic shift in the mathematics that students need in this increasingly technological society (National Research Council, 1989). According to America 2000 student achievement can be significantly impacted if we equip our schools with up-to-date technology and utilize this technology to improve student learning (1991).

Thus, the graphing calculators will allow students to create their own knowledge as advocated by NCTM. Dewey believed it was important to relate student’s mathematical studies to applications in their lives (1961). With our emphasis on constructivist thinking and real-world based learning activities, graphing calculators can make the handling of real world data an easier task because it enables students to construct many more graphs for observation and generalization than they could do by hand (Vonder Embse, 1992). "In fact, the intersection of calculator and computer technology, the graphing calculator, is an ideal environment for teaching and learning mathematics" (Vonder Embse, 1992, p. 65).
Research has shown that teaching experiments with graphing calculators are needed to study the fundamental concepts of mathematics (Shumway, 1990). Despite the evidence on the power of the graphing calculator in the mathematics curriculum, relatively few teachers are presently utilizing this technology in their instruction. According to the National Research Council these calculators have had virtually no impact on mathematics instruction (1989). "Mathematics educators can no longer continue with their educational heads in the sand while the world around them moves in a technological wonderland" (Carter, et. al, 1989, p. 8).

According to Hembree (1986) evidence of the promise of graphing calculators is only beginning to surface in the literature, and it is a topic of urgent need. NCTM also believes that research is needed to examine the interaction of technology with other instructional methods (1990). Further, Power On! (1988) urges that research should include studies on both the educational effectiveness and cost effectiveness of currently available technologies.

Therefore, it may be that mathematics educators are waiting for evidence that this technology is effective before implementing fully in their classrooms. Thus, there is a definite need for research studies in this area.

Summing up:
Shavelson observes that the contribution of educational research most often lies in constructing, challenging, and changing how policymakers and practitioners think. During this time of reform, the potential for mathematics education research; both to respond to the issues of practice and to challenge such thinking is enormous (1990, p. 290).

**Statement of the Problem**

The problem of this study was to determine the effect of the utilization of the graphing calculator on the achievement, attitude toward mathematics, and confidence in learning mathematics of Algebra II students.

**Hypotheses**

1. The mean score on a graphing skills test of a group of Algebra II students who have utilized the graphing calculator during instruction will be significantly higher than the mean score of a contrast group of Algebra II students who did not utilize the graphing calculator.

2. The mean score on the mathematics attitude scale of the Algebra II students who utilize the graphing calculator will be significantly higher than the mean score on the mathematics attitude scale of the contrast group of Algebra II students who did not utilize the graphing calculators.

3. The mean score on the confidence in learning mathematics scale of the Algebra II students who utilize the
graphing calculator will be significantly higher than the mean score on the confidence in learning mathematics scale of the contrast group of Algebra II students who did not utilize the graphing calculator.

**Definition of Terms**

**Attitude toward mathematics**, as used in this study, refers to the extent to which a student has a positive or negative attitude toward mathematics as measured by the Purdue Master Attitude Scale (Remmers, 1960).

**Confidence in learning mathematics**, as used in this study, refers to the extent to which a student has a positive or negative level of confidence toward their ability to learn mathematics as measured by the Fennema-Sherman Confidence in Learning Mathematics Scale (1976).

**Conic sections unit**, as used in this study, refers to the section of the Algebra II course that covers the graphing and equations of the parabola, circle, ellipse, and hyperbola.

**Graphing utility calculator**, as used in this study, refers to an instrument that combines the computer and the scientific calculator. This allows the graphing of functions on the screen of this hand-held calculator.
CHAPTER 2

REVIEW OF THE RELATED LITERATURE

Introduction

According to the National Council of Teachers of Mathematics (NCTM), one way in which achievement can be improved is for students to be actively engaged in the creation of their own knowledge (1989). This follows Dewey's emphasis on activity rather than passivity in learning (1959). This can be accomplished through the use of the graphing calculator (Demana & Waits, 1990b).

Evidence in educational research has shown that achievement is enhanced when students are taught with more "hands-on" experiences (Swartz, 1987). According to Piaget the problem with the teaching of mathematics is that the methods currently employed rely on symbolism and the use of the language of mathematics; however, logical mathematical knowledge can only develop if the child acts on objects (1970). Thus, one cause of failure in mathematics is starting with mathematical language instead of beginning with real and material action as advocated by Piaget (Sund, 1976). Piaget further asserts that there is no learning without experience and that students should be involved both physically and mentally in acting on what is being learned (Sund, 1976). Dewey would agree because he recommended that
teachers should attempt to bring about an adjustment between the learner and their environment by using procedures of "learning by doing" (1961). Graphing calculators allow hands-on experience because it transforms a math classroom into a lab with students investigating, making conjectures, and verifying findings (Standards, 1989). The use of graphing calculators allows students to see many different graphs, provides many opportunities to investigate all types of problems, and enables them to develop the ability to determine which approach is best in each situation. These behaviors are important in order to develop skills needed for successful achievement in mathematics.

Since achievement scores in mathematics have experienced a drastic decline in the past, evidently our current practices in the mathematics classroom are not effective. Therefore, innovation is needed in the mathematics curriculum. According to the National Council of Teachers of Mathematics the graphing calculator is a powerful tool to enhance understanding of algebraic concepts and in turn possibly raise achievement scores in mathematics (1989).

Since this study involves using the graphing calculator to teach the conic sections unit in Algebra II as well as the impact of these calculators on students' attitude and confidence toward mathematics, the review of the literature is divided into four sections: the teaching of mathematics
with the graphing calculator, utilization of graphing calculators to address the National Council of Teachers of Mathematics (NCTM) standards, attitude research in mathematics, and confidence research in mathematics.

**Teaching Mathematics with the Graphing Calculator**

This section is primarily concerned with the related literature concerning the need for the integration of technology in the mathematics curriculum, problem solving in real-world situations, understanding graphs and visualization, as well as exploring, constructing, and discovering mathematical concepts through graphing. Each of these ideas is explored as they relate specifically to the graphing calculator.

As Usiskin states "all recent national reports on school mathematics have recommended the incorporation of calculators and computer technology into the study of mathematics" (1993, p. 18). According to the Office of Curriculum and Professional Development at the Texas Education Agency (1989), in the next several years the general trends in math education include:

* an increased emphasis on student's solving relevant real-world problems.
* opportunities to connect the various branches of mathematics and to connect mathematics to other disciplines.
* the use of technology and other problem solving
tools in mathematics classrooms.

Also, three sections in the Algebra II Essential Elements (1991) advocate the use of graphing technology. These are:

2. (d) explore the effects of simple parameter changes on the graph of a quadratic function, using computer graphing techniques where appropriate.

3. (a) explore the graphs of algebraic representations of conic sections and make generalizations that allow classification of these algebraic representation as circles, ellipses, hyperbolas, or parabolas, using calculators or computers where appropriate.

3. (b) verify graphs of conic sections using computer graphing techniques where appropriate.

Next, according to the NCTM standards (1989) there are topics that should receive increased attention:

--Use of real-world problems to motivate and apply theory.

--The use of graphing utilities to develop conceptual understanding.

--Graphing utilities for solving equations and inequalities.

The topic that should receive decreased attention in Algebra according to NCTM is:
--Paper-and-pencil graphing of equations by point plotting.

Further, the Association of Supervision and Curriculum Development (ASCD) panel on United States achievement in math and science say science and math curricula should take better advantage of current technologies. In addition, one of the five competencies set forth in the Secretary’s Commission on Achieving Necessary Skills (SCANS) report is working with various technologies (Mullen, 1992).

Therefore,

the use of technologies must permeate teaching and learning. Daily and routinely our students either use technology or observe its use in their everyday lives. It is important that these useful tools become an integral part of the process of learning (Frye, 1990).

Finally, according to Schoen (1989), in order to meet all of the recommendations of the standards, calculators must be utilized more often.

Since many of today’s students will be using calculators and computers in some capacity when they enter the workforce, it is important that they receive training on this technology in school so that they will be ready to enter the world of work (Brady, 1991). As stated by Willoughby (1990) the most obvious reason to teach our students to use calculators is that they are all around us outside of school, and people who use them rarely use them
very intelligently. In mathematics it is repeatedly emphasized that we need to problem solve in real-world problem situations; graphing calculators can be used to incorporate such real world applications into the classroom (Eckert, 1989). As a result of technology, students are able to handle far more complicated, realistic noncontrived problem situations (Waits & Demana, 1988a). According to the standards, not only has the new technology made calculations and graphing easier, it has also changed the nature of the problems that are important and the way mathematicians choose to deal with such problems (NCTM, 1989).

A very crucial real world application with which every student should be familiar is graphing. According to Barclay, the National Assessment of Educational Progress (NAEP) has pointed out how poorly most students understand graphs (1987). In fact, a research study conducted by Schultz, et. al. (1986) found that students did not understand that a graph was different from drawing a picture of the information in the problem. Further, few high school students are able to connect algebraic and graphical representations of the same function, to interpret graphs accurately, or to understand functions and their graphs (Clement, 1985; Fey, 1984; Goldenburg, 1988). As stated in Power On!, "national test results show that students do poorly at graphing, despite the fact that graphing receives
considerable attention in both algebra and geometry" (1988, p. 54). As stated by Bell, "most secondary pupils are weak in the ability to interpret global graphical features" (1981, p. 34). Processing information in our highly technological society is becoming very dependent upon a person's ability to comprehend graphs (Curcio, 1987). Therefore, it is extremely important that graphical understanding become of utmost concern for mathematics educators (Goldenburg, 1988). We can expect the use of calculator graphing tools to elevate graphing to a primary position in the algebra curriculum (McConnell, 1988). In addition, the use of these graphing utilities will enable students to depict several graphs quickly and accurately which will allow them to make conjectures about emerging patterns (Owens, 1992). Graphing technology will be a powerful teaching device to demonstrate several graphs to a group which can generate a discussion on the differences or similarities (Carter, et. al., 1989; Kenelly, 1988). This is crucial since according to the College Entrance Examination Board (1985, p. 29):

The conception of functions is central to mathematics, and students entering college not only need to understand what functions are in general but also to be familiar with examples... They should be able to use computers and other tools (graphing calculators) to represent functions graphically.
With this emphasis on graphing, algebra instruction will become a more visual process. A key process in helping students improve TAAS scores is to provide opportunities for students to visualize (TEA, 1989). According to many sources in the literature, graphing calculators can give us the power of visualization to give meaning to many important algebraic techniques and help us to value mathematics by solving realistic interesting problems (Dick & Shaughnessy, 1992; Fey, 1989; Kaput, 1986; Schultz & Rowan, 1991; Wachsmuth & Becker, 1986; Waits & Demana, 1992; West, 1991). This is extremely important since approximately 50% of the student population we serve have preferred learning styles favoring visual experience over auditory ones and often struggle with the symbolic nature of math (Duren, 1990/1991; West, 1991). Graphing calculators are especially valuable for these students (Barclay, 1986; DiFazio, 1990). One school which used graphing utilities believed that this technology made it possible to see multiple representations of mathematic concepts such as numerical, graphic, and symbolic and that this process had positive effects on their students’ achievement (Lynch, et. al., 1989).

The powerful nature of graphing technology is also exemplified in its ability to help students make connections among the disciplines. "The graphing approach enables students to understand more clearly the connections between algebraic equation solving and graphical representation of
algebra" (Barrett & Goebel, 1990, p. 208). Good uses of graphic representations can help in performing algebraic computations (Goldenburg, 1988; Ruthven, 1989). Using graphing calculators makes the addition of geometric representation to the normal numerical and algebraic representations very natural (Demana & Waits, 1990c). This representation gives students and teachers the opportunity to explore the connection between algebra and geometry. After many guided experiences with graphs, the students will begin to see the relationships between algebra and geometry. Thus, instructors can expose students to much richer examples and exemplify the relationship between algebraic analysis and graphical analysis (Donley & George, 1993). The use of graphing calculators can promote "conceptual understanding of the mathematical connections between graphs and the algebraic expression or situation it represents" (Tate, 1990, p. 21).

As students begin making connections among the disciplines, they are exploring and discovering mathematic concepts. As discussed by Piaget, adolescents are in the formal operation stage which enables them to consider possible relations and, through experimentation, determine which relations are true (Glatthorn, 1987).

Piaget emphasized that children must perceive, talk about, and manipulate objects to develop intellectual abilities. First hand experience, however time
consuming, is the key to stable and enduring learning. What matters more than verbalizing rules and committing facts to memory is engagement in practical activities that call for problem solving (Strom & Bernard, 1982, p. 127).

With the new graphing technology, we can "have students explore and discover mathematical concepts, and use graphs to solve problems" (Demana & Waits, 1990c, p. 212).

As a result of this method, students gain more confidence with word problems and lose their negative attitude because they are empowered with the added technique of analyzing and solving these word problems graphically (Demana & Waits, 1990c). The Partnership for Access to Higher Mathematics (PATH) program (a pre-algebra curriculum utilizing graphing calculators) showed that statistically significant correlations were noted between student attitude and the use of calculator technology with achievement (Kennedy & Chavkin, 1992/1993). Further, these graphing utilities allow math teachers to involve students in constructing their own understanding of math concepts (McConnell, 1988). "The graphing calculators added a sense of excitement to the learning process as the students developed and tested their own conjectures" (Borenson, 1990, p. 637). Dewey asserts that education which is a reward for the learner is education that is interesting to the learner; the teacher should use specific subject matter to ignite the
interest of the learner (Artelle & Burnett, 1970). The use of these calculators will allow students to investigate many examples quickly and make and to test generalizations based on strong graphical evidence (Demana, et. al., 1992), tools which can be helpful in developing critical thinking skills.

As stated by Clement (1993) sixty percent of those responding to a Parade Magazine survey said that schools do only a fair or poor job of encouraging creative thinking and curiosity. Thus, there is a definite need for creative thinking, and these investigations will lead to students who can think critically because the "effective use of graphics calculators requires a solid understanding of the mathematical concepts involved, along with the ability to interpret the results critically. The graphics calculator is indeed a tool for critical thinking" (Dion, 1990, p. 567). As reported by Wachsmuth and Becker (1986), students become more reflective about their thinking and actions because they must organize their thinking and then take action when using the graphing calculator as a tool. Experts agree that "curriculums should support students' abilities to think critically and creatively and to solve problems--in short, to become active learners" (O'Neil, 1990, p. 8).

As students begin to understand geometric properties and graphical relationships and become more critical thinkers, this will impact their testing capabilities. The
Texas Assessment of Academic Skills (TAAS) objectives for 1990-1995 include:

* demonstrate an understanding of mathematical relations, functions, and algebraic concepts.
* demonstrate an understanding of geometric properties and relationships (TEA, 1989, p. 6).

Further as stated by TEA, "even though calculators are not yet used on TAAS, students may benefit from using calculators during class" (TEA, 1989, p. 8). Also beginning in March 1994, calculators will be allowed on the Scholastic Aptitude Tests (SAT) (Usiskin, 1993).

In conclusion, if these calculators can impact problem solving in real-world situations, enable students to visualize and understand graphs, make connections among the disciplines, explore and discover math concepts, and perform better on achievement tests according to the previously mentioned research, then it should also impact achievement, attitude, and confidence of students. The purpose of this study is to determine whether Algebra II students’ achievement in a conic section unit is greater when the graphing utility calculator is incorporated into this unit of instruction. If achievement is impacted, teachers will be more motivated to infuse technology, such as the graphing calculator, into their mathematics instruction. Further, if attitude and confidence are impacted by the use of the
graphing calculator, this will give teachers more legitimate reasons to integrate this technology into their classrooms.

**Utilization of Graphing Calculators to Address the NCTM Standards**

A brief synopsis of the research follows to establish a rationale for the use of graphing calculators to implement the four general assumptions presented in the *Curriculum and Evaluation Standards of School Mathematics* (1989). These assumptions are (1) increasing problem solving, (2) developing communication skills in mathematics, (3) developing logical reasoning, and (4) establishing relationships between differing mathematics courses such as Algebra and Geometry.

Problem solving is the first assumption. According to the standards "to solve a problem is to find a way where no way is known off-hand, to find a way out of a difficulty, to find a way around an obstacle, to attain a desired end that is not immediately attainable, by appropriate means" (Standards, 1989, p. 137). Math exploration and problem solving must have a more central position in the study of mathematics. In Algebra the focus is shifting from the manipulation of numerical expressions to include an increased emphasis on understanding concepts and using Algebra as a way to represent mathematical situations and relationships (Thompson & Rathmell, 1988). With graphing calculators students can investigate many math concepts and
relationships. This helps students become better decision-makers about the best way to approach each situation (Duren, 1989). Further, students must be given many opportunities to investigate all types of problems so that they can develop the ability to determine which approach is best in each situation. Graphing calculators are very powerful as problem solving devices that allow students to make and test generalizations by looking at a large number of examples in a short period of time (Demana & Waits, 1988a; Demana & Waits, 1988b). There is some evidence that students who use graphing calculators become better problem solvers and develop a more thorough understanding of algebraic concepts and procedures (Demana and Waits, 1990a; Johnson, 1988).

The second assumption, in an approach to better understanding of mathematics, is the ability to communicate in mathematics. As lecturers, teachers do the majority of talking while students remain passive recipients of knowledge. In order to facilitate learning we must move away from the lecturer format and engage every student in the discourse in the classroom. "The study of mathematics should include opportunities to communicate so that students can model situations using oral, written, concrete, pictorial, graphical, and algebraic methods" (NCTM, 1989, p. 78). Since the mathematics section of the Texas Assessment of Academic Skills (TAAS) requires students to utilize these
types of skills, it is important for teachers to address this need. This can be accomplished through posing questions and tasks that engage and challenge the thinking of the students, listening carefully to students' ideas, asking for clarification and justification of those ideas, making a decision about which of the ideas to pursue, and monitoring and encouraging all students to participate (Standards, 1991). Due to the introduction of the graphing calculator, the instructor goes from lecturer to facilitator of learning, and students become active partners in the learning process (Demana & Waits, 1990b; Waits & Demana, 1988a).

As active partners in the learning process, students can also begin to achieve the third assumption: developing logical reasoning. According to Demana and Waits, (1990b) logical reasoning can be enhanced by using the guided discovery method of teaching in combination with the graphing calculators. Graphing calculators transform a math classroom into a lab with students investigating, making conjectures, and verifying findings (Standards, 1989). The Curriculum and Evaluation Standards for School Mathematics (1989) also suggest that the teacher who utilizes the graphing calculator will encourage experimentation and provide for students to summarize ideas and to establish connections with previous knowledge. This is using what Dewey refers to as reflective thinking whereby a student
works "to transform a situation in which there is experienced obscurity, doubt, conflict, disturbance of some sort into a situation that is clear, coherent, settled, harmonious" (1933, p. 100-101). This will lead to the student’s development of logical reasoning.

Along with logical reasoning, the NCTM Commission for Standards for School Mathematics feel the fourth assumption is establishing relationships between differing math topics such as algebra and geometry. Graphing technology makes the addition of geometric representation to usual numeric and algebraic representations very natural (Demana & Waits, 1990b).

Advanced graphing technology is the vehicle that allows both teachers and students to make important connections among the algebraic, numerical, and graphical representations (Vonder Embse, 1993, p. 592).

Integration of ideas in Algebra and Geometry is strong with the representation of graphs playing a connecting role (Standards, 1989). Thus, students can use graphing calculators to see algebraic problems more geometrically and can make connections between mathematical concepts that they would never make if they had to laboriously draw each graph by hand (Trotter, 1991). Graphs can be generated quickly with a graphing calculator, and many graphs can be seen in a short amount of time according to Demana and Waits (1989).
This provides students the opportunity to explore patterns much easier than was possible only a few years ago (Erickson, 1992). This allows students to investigate problems more thoroughly; in this setting, opportunities are provided for students to summarize ideas and to establish connections with previously studied topics. Last, the effects of certain parameters on graphs will enable students to see a connection between algebra and geometry. The use of graphing calculators help students understand the many connections between different representations of the same problem; according to Bruner our curriculum should be most concerned with facilitating this transfer of learning (Glatthorn, 1987).

Thus, the thought processes involved in utilizing a graphing calculator can enable students to accomplish the goals of the "standards" (Heid, 1990). Although these goals will not be achieved quickly, one of the most effective ways that the standards can be approached is with the use of a graphing calculator. Therefore, Algebra instruction can focus more readily on the four assumptions aforementioned, teachers can engage students in reasoning and exploring real life problems, and make great strides toward implementing the standards with the use of a graphing calculator.

Attitude Research in Mathematics

According to Aiken, the term "attitude" means approximately the same as enjoyment, interest, and to some
extent, level of anxiety toward mathematics (1972).
Further, Aiken believes that more meaningful teaching should improve attitudes toward mathematics. The following discussion includes the research on mathematics and attitude over the past two decades. Since this study focuses on secondary mathematics, the research included will be subdivided into research conducted in junior high schools, high schools, and colleges.

The attitude research in the junior high school has focused on three distinct areas. These areas were utilizing hands-on materials in the classroom, differing instructional strategies, and learning environment as they relate to attitude toward mathematics.

Hands-on materials employed in the classrooms were software packages, learning materials to match learning styles of the students, science laboratory equipment, and calculators. The research on software packages in mathematics instruction, as it relates to attitude toward mathematics, produced mixed results. A study conducted by Junker (1990) in which a problem-solving software package was utilized to teach mathematics had no significant impact on attitudes toward mathematics. The two studies investigating the use of calculators to teach mathematics also did not show a significant gain in attitude toward mathematics (Aldridge, 1991; Brekke, 1991). However, two further studies on using LOGO to teach geometry skills both
showed a significant gain in attitude toward mathematics (Cook, 1988; Yusuf, 1991). Further, the use of hands-on learning materials to match students’ learning styles also produced a significant gain in attitude toward mathematics (Bryant, 1990). In addition, a study in which science laboratory equipment was used to teach mathematics also revealed a significant gain in attitude toward mathematics (Higgins, 1970).

The second area of research in attitude toward mathematics in the junior high school focused on differing teaching strategies. Two studies on cooperative learning in the math class showed no significant gain in attitude toward mathematics (Davis, 1989; Dubois, 1991), while one cooperative learning study showed significant gain in attitude toward mathematics (Miller, 1990). A study using master learning and wait time also showed significant gains in attitude toward mathematics (Olson, 1989). Another strategy employed was active participation in math classes which resulted in significant gains in attitude toward mathematics (Kutscher-Kotzer, 1989).

The third area of junior high school mathematics attitude research is concerned with the learning environment. A study conducted by Haladyna, Shaughnessy, and Shaughnessy concluded that teacher quality had a significant impact on mathematics attitude while management-
The research in attitude toward mathematics in the junior high school shows both positive and negative impact; however, there were some particular areas in which most of the results were positive. The area that showed the most positive promise were active participation by students with hands-on materials such as LOGO to teach geometry, matching learning styles and materials, and science lab equipment to teach mathematics. Thus, as mathematic teachers we should endeavor to incorporate such hands-on materials into our junior high classrooms.

There was a wealth of research in mathematics attitude in the high school. This research focused on four distinct areas. These areas were utilizing differing curricula, varied instructional methods, hands-on materials, and pre-instructional innovative activities as each of these relate to attitude toward mathematics.

The high school research utilizing differing curricula came in two forms. The first of these was using a particular textbook to teach mathematics, and the other form utilized a particular curriculum to teach courses. Both forms yielded positive as well as negative results. There were three studies on Algebra I curriculum utilizing the Saxon textbook versus other textbooks. These studies resulted in no significant gain in mathematics attitude
(Flexer, 1991; Lawrence, 1992; Denson, 1990). Another study of a new program for students who are not enrolled in pre-college mathematics courses showed no gain in attitudes toward mathematics (Alquiza, 1990). Similarly, a study comparing three curricular variations - a Math-Science oriented program, a broad-based college preparatory program, and a regular general track secondary school - showed no significant gains in mathematics attitude (Gomes, 1991). The research that produced positive attitude gains also came in both curriculum forms. Hirschhorn conducted one such investigation of the University of Chicago School Mathematics Project (UCSMP) secondary curriculum in which a significant gain in mathematics attitude was found only in the portion of this curricula which dealt with calculator use (1992). In addition, a study utilizing curriculum materials to implement the NCTM standards in consumer math showed significant gains in mathematics attitude (Zech, 1990), and an application-oriented algebra curriculum revealed a significant gain in attitude toward mathematics (Swafford & Kepner, 1980). Likewise, a study of remedial math curricula for low achieving ninth graders showed a significant gain in attitude toward mathematics (Stegall, 1992).

The second area of high school mathematics attitude research was concerned with instructional methods. Two studies concerned with Algebra instruction resulted in
opposite results. The first study was conducted by Smith (1993) and involved using problem solving vignettes in Pre-Algebra instruction which showed no gain in attitude toward mathematics while the study conducted by Staltare (1991) in which videotapes were used to enhance Algebra I instruction showed significant gains in attitude toward mathematics. Three studies conducted in geometry classrooms all showed no significant gains in attitude toward mathematics. These studies were using drawing activities in geometry (Brainerd, 1992), 4MAT to teach geometry (Szewczyk, 1988), and teaching geometry with transformations (Usiskin, 1972). In a meta-analysis of fifteen instructional strategies conducted by Bradford (1991), significant gains in mathematics attitude were correlated with discovery learning, innovative word problems, and problem solving.

By far the largest area of research in high school mathematics attitude was in the area of hands-on materials to teach mathematics. This area can be further subdivided into computer assisted instruction, calculator instruction, learning styles materials, and simulations. The research on computer assisted instruction was conducted in all levels of classrooms ranging from remedial ninth grade mathematics through precalculus. In ninth grade remedial classrooms, there were no significant gains in attitude toward mathematics when computers were used in mathematics instruction (Thayer, 1992; Reagan, 1992; Lee, 1992).
However, in a study of computer utilization in all ninth grade classrooms conducted by Robitaille, Sherrill, and Kaufman (1977), a significant gain in mathematics attitude was found. In Algebra I instruction there were mixed results. A study conducted by Cole (1992) in which Hypercard was utilized in Algebra I word problem instruction showed no significant gain in mathematics attitude while a study conducted by Wohlgehagen (1992) revealed a significant gain in attitude toward mathematics with computer based instruction. Geometry with computer based instruction showed gain in attitude toward mathematics in all four studies reviewed. The first study was a technologically rich geometry classroom (Bolin, 1992); next LOGO was used to teach informal geometry (Cook, 1988); problem solving software was used in geometry in a third study (Funkhouser, 1991); and finally computer graphics aided in teaching functions and transformational geometry (Thomas, 1990). Algebra II instruction utilizing computer based methods showed varied results. The first study investigated the effectiveness of carefully designed teacher training on using the computer in instruction and the consequent students' attitudes toward mathematics which resulted in no significant gain in attitude toward mathematics (Loop, 1990). Another study on computer-enhanced resources throughout an entire Algebra II course had no significant effect on attitudes toward mathematics (Saunders & Bell,
A third study reviewed used two forms of computer based instruction to teach Algebra II and resulted in significant gains in attitude toward mathematics (Wood, 1991). A study in precalculus using computers for independent exploration also had no significant impact on attitude toward mathematics (Rosenbloom, 1991). A study conducted of trigonometry, precalculus, and calculus students who utilized computers in mathematics instruction resulted in a significant gain in attitude toward mathematics (DeBlassio & Bell, 1981).

The second area of research on hands-on materials in the high school as related to mathematics attitude is in the area of calculator use to teach mathematics. The four studies reviewed on ninth grade mathematics yielded differing results. One study used desk calculators in ninth grade general mathematics and there was no significant gain in attitudes toward mathematics (Cech, 1970). Another study on non-college bound students and the effect of using calculators on their computational abilities showed no significant gains in mathematics attitudes (Lim, 1992). However, a ninth grade general mathematics' study utilizing calculators in mathematics instruction showed a significant gain in attitude toward mathematics (Gaslin, 1975). In addition, a study in Algebra I to determine whether there was a difference in basic skills maintenance between students who used calculators and those who did not showed a
significant gain in mathematics attitude (Whisenant, 1990). In a study of the effect of graphing calculators on the learning of function concepts in precalculus, there was a significant gain in attitudes toward mathematics (Rich, 1991). A further study of the graphing calculator in an introductory calculus course also revealed a dramatic increase in confidence in students' abilities to solve real world problems (McClendon, 1992).

The last two areas of hands-on materials in research are learning styles materials and simulations. The first of these was conducted to determine if personalized remediation strategies based upon learning styles was effective in improving attitudes in mathematics. A significant gain was found (Angell, 1993). In addition, the study on simulations investigated the effects of the Simulations That Address Remedial Teaching (START) program on attitude toward mathematics of ninth grade remedial mathematics students; significant gains were found (Gerver, 1990).

The final area of high school mathematics attitude research is concerned with pre-instructional activities in mathematics instruction. The first study involved using dialogue journals in Algebra I; no significant gains in mathematics attitudes resulted (Andrews, 1990). In another study eleventh grade students were taught how to use relaxation and guided imagery and showed significant gains in attitude toward mathematics as a result (Field, 1989).
Although high school mathematics attitude research yielded varying results, there were some commonalities. The most positive gains occurred in studies involving calculator and graphing calculator use, an application oriented Algebra program, discovery teaching methods, computer assisted learning from ninth grade general math through calculus, learning styles materials, and simulations. Thus, as discussed in the review of the junior high mathematics attitude research, the most positive gains in mathematics attitude occurred in the area of hands-on active student involvement.

The last area of mathematics attitude research reviewed was conducted in colleges. The attitude research focused on two areas in colleges. These areas were hands-on materials and instructional strategies.

Hands-on materials in mathematics attitude research all reported positive gains in attitude toward mathematics. One study investigated the results of computer assisted instruction versus lecture method to teach mathematics (Netusil & Kockler, 1974). Another study compared four types of feedback to student responses on a computer assisted instruction unit to teach functions (Schoen, 1972). A third study investigated the effect of a computer algebra system on students' problem solving abilities (Trout, 1993). Similarly, another study investigated the effects of a computer algebra system on students' comprehension and
computational skills in Calculus I (Schrock, 1990). A final study used the graphing calculator to teach a trigonometry class by including an increased number of realistic applications (Army, 1992).

The instructional strategies employed in college mathematics instruction showed differing results in attitudes toward mathematics. A study investigating cooperative learning in college algebra showed no gains in mathematics attitude (Gentry, 1992). Further, a study to determine whether audio-visual tutorial instruction was more effective than traditional instruction resulted in no gains in mathematics attitude (Grove, 1988). However, a study investigating the increase of confidence in basic math skills resulted in a gain in mathematics attitude (Konvalina, 1980).

Mathematics attitude research in colleges appears to follow the same lines as the junior high and high school research in that computer assisted instruction and graphing calculators had the greatest positive effect on attitude toward mathematics. Therefore, hands-on materials are extremely powerful in affecting students' attitudes toward mathematics.

Thus, the attitude research just reviewed lends itself to the premise of the previous research covered in this literature review which stated that learning can be enhanced with hands-on methods. Evidently, attitude is equally
enhanced with these same hands-on active involvement methods. Educators should be careful to keep this in mind in their mathematics instruction because all too often mathematics is still taught primarily with symbols and no hands-on experiences whatsoever.

Confidence Research in Mathematics

As science and technology have come to influence all aspects of life, mathematics has come to be of vital importance to the educational agenda of our nation. Mathematics is the foundation of science and technology. Evidence shows that three out of four Americans stop studying mathematics before completing career or job prerequisites. Perhaps this is because many students lack confidence in their ability to succeed in mathematics courses and careers. Due to this lack of confidence, the United States faces a serious shortage of people with skills necessary to sustain and to develop the advanced technology on which our society depends. Thus, it is of extreme importance that we conduct confidence in mathematics research to affect this lack of confidence.

Confidence in mathematics research is far less abundant than mathematics attitude research particularly as it relates to interventions in the classroom to affect a student's confidence. According to Konvalina (1981) there has been very little research concerning confidence in mathematics. This situation seems to prevail even ten years
later when this review was conducted. This review will cover the research on confidence in mathematics conducted in the junior high school, high school, and colleges in much the same way as the previous section concerning attitude toward mathematics.

The confidence research in the junior high focused on using a motivational seminar to increase confidence in mathematics. Blum-Anderson (1991) conducted a study in which an intervention approach was designed to increase eighth graders confidence in learning mathematics. This intervention included a three day motivational seminar and resulted in a change in the positive direction in student confidence in learning mathematics (Blum-Anderson, 1990).

The high school mathematics confidence research can be subdivided into three areas. These areas are instructional strategies, student characteristics, and hands-on instructional materials.

There were two differing instructional strategies discovered in this review, both of which showed gains in confidence in learning mathematics. One study examined the impact of teacher attitudes and behaviors on students' confidence and utilized the data gathered in the Second International Mathematics Study (Milosheff, 1992). Findings in this study suggested that student self-confidence in mathematics was positively influenced by the discovery method of teaching (Milosheff, 1992). Another study used
routine and non-routine word problems to determine if there was a relationship between gender and confidence in mathematics, and a positive relationship was discovered (Caporrimo, 1990). In this study males with higher confidence scores also had higher achievement scores while female’s higher confidence scores were unrelated to their achievement scores (Caporrimo, 1990).

The next area of confidence in mathematics research was student characteristics and their relation to confidence in mathematics. This study investigated the relationship between a female student’s spatial skills and athletic participation as these relate to mathematical confidence (Trudnowski, 1993). Both spatial skills and participation in athletics had a positive effect on confidence in learning mathematics (Trudnowski, 1993).

The greatest amount of mathematics confidence research is in the area of hands-on instructional materials. All of the studies investigated showed positive gains in confidence toward mathematics. One study conducted by Wohlgehagen (1992) investigated the impact of computer-based instruction in Algebra I as contrasted with traditional instruction. Wohlgehagen (1992) found a significant difference in confidence in learning mathematics in the computer based instruction (treatment) group. Two studies investigated the effect of the graphing calculator on confidence in mathematics. The first study utilizing the graphing
calculator in precalculus instruction found a gain in confidence in mathematics scores in the treatment (graphing calculator) group (Dunham, 1991). A second study conducted by McClendon (1992) investigated the effect of graphing calculator instruction in calculus which showed a dramatic increase in students' confidence in their abilities to solve real world problems.

College mathematics confidence research focused on interventions in the classroom and their effect on a student's confidence in mathematics. A study conducted by Konvalina (1981) investigated the effect of a periodic self-assessment of confidence in basic math skills and its effect on students' confidence in mathematics. This study showed a gain in confidence in the experimental group (Konvalina, 1981). A second study investigated two intervention methods on a student's confidence in their ability to do mathematics, statistics in particular (Forbes, 1989). One of the interventions was a pilot program in the psychology department to help students deal with apprehension about required statistics courses (Forbes, 1989). The students were randomly assigned to either one of four counseling-based statistics confidence groups, to one of three statistics tutoring groups, or to a non-treatment control group; the counseling-based statistics confidence groups showed significant gains in confidence toward mathematics (Forbes, 1989). The third study investigated the
relationship between gender and confidence in mathematics; a statistically significant difference was found between gender and confidence in favor of the males in the study (Lofland, 1992).

Although there were several studies that resulted in positive gains in confidence toward mathematics, the most positive results again occurred in the area of hands-on materials in mathematics. The areas that showed the greatest gains were discovery teaching methods, computer based instruction, and graphing calculators in mathematics instruction. Therefore, the previous research is once again supported by the research on confidence in mathematics.

Summary

Since the previous review of the literature confirms the fact that hands-on instructional materials positively affect achievement, attitude, and confidence in mathematics, perhaps teachers will be more likely to try hands-on techniques in the classroom. One powerful hands-on tool that can be incorporated into the mathematics classroom is the graphing calculator. If teachers are shown that the graphing calculator can help them implement the standards in their classroom and if more training is available, as well as ongoing support, perhaps they would be more likely to integrate this technology into their classrooms. Further, if it is proven to teachers that the use of graphing calculators can lead to positive gains in attitude and
confidence in mathematics, then they will have another viable reason to utilize these calculators in their classrooms. This is imperative due to the mandate from the Texas Education Agency (TEA) dated September 29, 1993. In this mandate all districts must provide students with graphing calculators and training on the graphing calculators by the 1995-1996 school year in order for the students to use these calculators on the Algebra I end-of-course exam (TEA, 1993). Thus, teachers must become well versed in the use of these calculators. Furthermore, since there is little research available on the effect of the use of the graphing calculator on achievement, attitude, and confidence this study will add to the knowledge base.
CHAPTER 3

RESEARCH METHODOLOGY

Introduction

This chapter presents a description of the methods and procedures used to collect and analyze the data. It includes discussions of the general population, the instrumentation, the research design, and the procedures for the data analysis.

Population

The population for the study consisted of all the students from eight intact Algebra II classes from two closely matched high schools in two 4-A suburban districts in North Texas. The teachers were volunteers who agreed to teach part of their classes with the graphing calculator and part of their classes without the graphing calculator for the conic sections unit. The two teachers at High School A were each teaching two classes of Algebra II at the time of the study, and the one teacher at High School B was teaching four classes of Algebra II at the time of the study. At High School A, one of each of the teacher’s classes was chosen at random as the experimental (graphing calculator) group, and the other class was the control (non-graphing calculator) group. At High School B, two of the teacher’s
classes were chosen at random as the experimental (graphing calculator) group, and the other two classes were the control (non-graphing calculator) group. The students involved in the study were tenth, eleventh, and twelfth graders ranging in age from sixteen to eighteen years old. The two high school groups were compared on the basis of the mathematics section of the tenth grade Texas Assessment of Academic Skills (TAAS) in order to establish group equivalency. The table that follows shows the results of the t-test of independent samples. The p-value of .1641 indicates there was no significant difference between the populations based upon the comparison of the Texas Assessment of Academic Skills (TAAS) mathematics scores.

Table 1

**Comparison of Populations Utilizing TAAS Scores**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School A</td>
<td>82</td>
<td>1600.13</td>
<td>117.30</td>
<td></td>
</tr>
<tr>
<td>High School B</td>
<td>104</td>
<td>1582.42</td>
<td>116.10</td>
<td>.1641</td>
</tr>
</tbody>
</table>

The experimental group originally consisted of eighty-eight students, but two of the students were not included in the study because they left school before the study was completed. The final number of students in the experimental group was eighty-six. The experimental group contained four students who were tenth graders, seventy students who were
eleventh graders, and twelve students who were twelfth graders. The mathematics TAAS scores for this group ranged from 1360 to 1930. The mean mathematics TAAS score for the experimental group was 1579.88.

The control group originally consisted of eighty-seven students, but three students were not included in the study because they left school before the study was completed. The final number of students in the control group was eighty-four. The control group consisted of four students who were tenth graders, seventy-two students who were eleventh graders, and eight students who were twelfth graders. The mathematics TAAS scores for the control group ranged from 1390 to 2220. The mean mathematics TAAS score for the control group was 1597.86.

Instrumentation

There were three tests chosen for this study by the researcher. The first test chosen was used to measure achievement in conic sections, the next measured attitude toward mathematics, and the last measured confidence in learning mathematics. Copies of these tests are included in Appendix 3. Each of these tests will be discussed in the following sections.

To test math achievement, the researcher used the Test of Graphing Skills developed by Loop (1990). According to Loop (1990), content validity for this test was established by a group of ten Algebra II teachers. These teachers were
given a rating sheet and asked to rate each test question on a five point scale ranging from "very poor" to "very good". Further, reliability was established by a pilot test involving forty-five students who were given the graphing skills test twice, with a month intervening, and a statistical analysis showed a .0001 p-value which indicated a high degree of correlation between the initial test and the corresponding final test scores (Loop, 1990).

Students in the experimental group and the control group took the Test of Graphing Skills only as a post-test. This test has a time limit of twenty-five minutes in order to determine if the graphing calculator has had an impact on the assimilation of the conic section relationships. In this way, the students will not have time to plot and graph each equation by hand; they are forced instead to use what they know about the relationships between the coefficients in the standard form of the conic section to determine the correct answer.

Students' attitudes towards mathematics were assessed with the Purdue Master Attitude Scale (Reemer, 1960). Both groups were given Form A before the treatment as a pre-test and Form B after the treatment as a post-test. This survey measures attitude toward any school subject and was used to test students' attitude toward mathematics. It is a seventeen item Thurstone-type scale where students select the statements with which they agree. These statements
begin positive, become neutral, and then negative. Validity and reliability are discussed at length in the Purdue Master Attitude Scale Manual that accompanied the scale. Face validity of the survey indicated that there were almost perfect correlations between this scale and the Thurstone scale. Further, in numerous studies this scale was successful in differentiating among attitudes that differ.

Students’ confidence in learning mathematics was assessed by utilizing the Fennema-Sherman Confidence in Learning Mathematics Scale (1976). Both groups were given this test as a pre-test before the treatment and after the treatment as a post-test. This survey measures a student’s confidence in learning mathematics. Fennema & Sherman established content validity by defining each scale dimension. Next, each author wrote items representing each dimension and then judged the validity of the other author’s items. The final version of the Confidence in Learning Mathematics Scale had a split half reliability of .93 (Fennema & Sherman, 1976).

Research Design

The researcher conducted a quasi-experimental study using an experimental group and a control group of Algebra II students. The following diagram represents the design of the study where 0 = pre-test/post-test measures and X = the treatment.
Treatment Group:  O  X  O
Contrast Group:  O  X  O

The treatment consisted of the integration of graphing calculators in the instruction of the conic sections unit in Algebra II classrooms. This unit encompassed approximately six weeks of instructional time from the middle of February until the end of March in which the graphing calculator was used daily in the instructional process. Thus, this unit was taught from the middle of the fourth six weeks grading period until the middle of the fifth six weeks grading period.

Each of the teachers in the study taught both the experimental group and the control group. Therefore, all teachers received two full days of inservice on the graphing calculators with hands-on practice and suggestions for use in a conic sections unit prior to the time for the study to begin. The first of these full day inservice sessions was conducted on a Saturday in December, and the second full day session was conducted on a Saturday in January. During the initial training session the teachers were provided lesson plans with questioning suggestions to help them implement the graphing calculator into their conic sections unit. The teachers were instructed to work all problems in the conic sections unit provided before the next full day inservice in January. The second full day inservice was utilized to answer any questions the teachers had concerning the lesson
plans provided. In addition, this second inservice provided further hands-on practice with the graphing calculator and conic sections problems. Further, the researcher met with each of the teachers once a week during implementation for assistance with calculators and implementation of lesson plans.

The teachers distributed the consent forms prior to the beginning of the study in January (Appendix 1). Each student was asked to take home a parent consent form as well as a student consent form to review with their parents. Both forms must be returned in order to participate in the study. Both of the forms supplied permission for the student to respond to the three measuring instruments included in the study. Further, the parent consent form allowed the researcher to examine the Texas Assessment of Academic Skills (TAAS) mathematics data in order to establish group equivalency in the student population of the two high schools. In both high schools all consent forms were returned. The researcher attributes this high return rate to a reward system in which students received a coupon when they returned the forms. The students could redeem the coupon for tangible items such as candy, pencils, pens, and folders.

The teachers administered pre-tests to measure attitude toward mathematics and confidence in learning mathematics to the students in the experimental group and the control group
prior to the beginning of the conic sections unit. There was not a pre-test administered for the graphing skills test because the researcher utilized the Texas Assessment of Academic Skills (TAAS) mathematics scores as the covariate for that measure rather than a conic sections pre-test.

Students in the experimental group were taught the conic sections with the supplied lesson plans (Appendix 4) by using the graphing calculator while the students in the control group were taught with the same lesson plans without utilizing the graphing calculator. Each student in the experimental group was given a graphing calculator to keep and use throughout the study. When the unit was completed, the teachers administered three post-tests to the students in the experimental group and the control group. The post-tests measured attitude toward mathematics, confidence in learning mathematics, and achievement in conic sections.

Data Analysis

Data were collected three times during the study from all students in the experimental group and the control group. The pre-tests were given prior to the study and the post-tests were given at the end of the study. The third source of data were the student’s records where the researcher gathered TAAS mathematics scores to be utilized to establish group equivalency and as the covariate for the graphing skills test analysis rather than using a pre-test for that measure.
The test of graphing skills was administered, as a post-test only, to both the experimental group and the control group. An Analysis of Covariance (ANCOVA) was applied to see if there was a significant change in student achievement in the Algebra II conic sections unit where the independent variable is "using graphing calculators in the Algebra II conic sections unit" or "not using graphing calculators in Algebra II conic sections unit". The dependent variable is the graphing skills test, and the covariate is the TAAS mathematics score. Since ANCOVA is a statistical procedure that compares the means of two groups while adjusting for differences among the groups, this method is useful when the groups are initially unequal which can happen without random assignment (Vockell, 1983). Therefore, ANCOVA allows the population groups to be even more closely matched than the demographics previously mentioned.

Also data were collected on change in students' attitude toward mathematics. All students were given Form A as a pre-test before the treatment using the Purdue Master Attitude Scale (Remmers, 1960) and a post-test with Form B of the same instrument approximately six weeks later at the end of the study. An Analysis of Covariance was used to determine significant change in students' attitudes toward mathematics.
Further, data were collected on change in students' confidence in learning mathematics. All students took a pre-test using the Fennema-Sherman Confidence in Learning Mathematics Scale (1976) before the treatment, and a post-test with the same instrument was administered approximately six weeks later at the end of the study. An Analysis of Covariance was used to determine significant change in students' confidence in learning mathematics.
CHAPTER 4

PRESENTATION AND ANALYSIS OF DATA

Introduction

This chapter reports the findings of the research and presents the data in two sections. The first section presents the results of the pre-test comparison of the experimental group and the control group to determine if the two groups were equivalent before the treatment with respect to achievement, attitude, and confidence. The second section presents the results of the post-test comparison of the experimental group and the control group to determine if there were measurable differences between the two groups that can be attributed to the treatment. Therefore, the researcher addressed the following analyses:

1. Data were used to determine any difference on the achievement of graphing skills between the experimental (graphing calculator) group and the control (non-graphing calculator) group.

2. Data were analyzed to discover if there were any differences in the students' attitude toward mathematics between the experimental (graphing calculator) group and control (non-graphing calculator) group.

3. Data were used to compare the experimental (graphing calculator) group's confidence in learning
mathematics to the control (non-graphing calculator) group's confidence in learning mathematics to determine if the experimental group showed a significant change in their confidence in learning mathematics as compared to the control group.

**Pretreatment Analyses**

In order to determine if there existed a significant difference between the experimental group and the control group prior to the treatment, the researcher conducted an analysis of the pretreatment data. To determine significant achievement differences, Texas Assessment of Academic Skills (TAAS) mathematics results were compared, Purdue Attitude Toward Mathematics pre-test scores were compared to determine differences in attitude, and the Fennema-Sherman Confidence in Learning Mathematics pre-test scores were compared to determine any differences in confidence between the two student groups prior to the beginning of the treatment.

**Achievement Data Analysis**

Using the TAAS mathematics scores for each student in the experimental group and the control group, the researcher conducted a t-test of independent samples to determine if there existed a statistically significant difference in achievement between the two groups prior to the treatment. As shown in Table 2, the result reveals a p-value of .2005,
which exceeds the 5% significance level. Therefore, there was no significant difference in the achievement of the experimental group and the control group prior to the treatment.

Table 2
Comparison of the Pretreatment TAAS Mathematics Scores of the Two Student Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>86</td>
<td>1579.88</td>
<td>132.20</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>84</td>
<td>1597.86</td>
<td>145.97</td>
<td>.2005</td>
</tr>
</tbody>
</table>

Attitude Toward Mathematics Data Analysis

Attitude toward mathematics was measured with the pre-test Purdue Master Attitude Scale prior to the treatment. These scores were analyzed using a t-test of independent samples to determine if there existed a statistically significant difference in attitude of the two groups prior to the treatment. As shown in Table 3, the result reveals a p-value of .1228, which exceeds the 5% significance level. Therefore, there was no significant difference in the attitude of the experimental group and the control group prior to the treatment.
Table 3

Comparison of the Pretreatment Attitude Toward Mathematics Scores of the Two Student Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>86</td>
<td>6.7753</td>
<td>1.8745</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>84</td>
<td>7.1190</td>
<td>1.9705</td>
<td>.1228</td>
</tr>
</tbody>
</table>

Confidence in Learning Mathematics Data Analysis

The students in both the experimental group and the control group were given a pre-test Confidence in Learning Mathematics Scale prior to the treatment. A t-test of independent samples was conducted by the researcher to determine if there existed a significant difference in confidence between the groups prior to the treatment. As shown in Table 4, the result reveals a p-value of .2137, which exceeds the 5% significance level. Therefore, there was no significant difference in confidence of the experimental group and the control group prior to the treatment.
Table 4

Comparison of the Pretreatment Confidence in Learning Mathematics Scores of the Two Student Groups

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>86</td>
<td>49.28</td>
<td>18.27</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>84</td>
<td>51.44</td>
<td>17.13</td>
<td>.2137</td>
</tr>
</tbody>
</table>

Posttreatment Analyses

When the treatment was concluded, students' graphing skills achievement, attitude toward mathematics, and confidence in learning mathematics were measured and data were analyzed according to the instruments described in detail in Chapter 3. The three hypotheses stated in Chapter 1 of the study were tested.

Achievement in graphing skills was tested using Loop's Graphing Skills Tests (1990). This test was given as a post-test after the treatment. An analysis of covariance (ANCOVA) was used to determine if there was a significant difference between the experimental group and the control group after treatment. The TAAS mathematic score was used as the covariate, and the post-test score was the dependent variable.

The Purdue Master Attitude Scale was used to test the attitude of the student involved in the study. Form A was given as a pre-test prior to the treatment, and Form B was
given as a post-test at the end of the treatment. ANCOVA was used to determine if there was a significant difference between the experimental group and the control group after the treatment. The pre-test was used as the covariate, and the post-test score was the dependent variable.

Confidence in mathematics was measured using Fennema-Sherman’s Confidence in Learning Mathematics Scale. This test was given as a pre-test before the treatment and again as a post-test after the treatment. ANCOVA was used to determine if there was a significant difference between the experimental group and the control group after the treatment. The pre-test was used as the covariate, and the post-test score was the dependent variable.

**Hypothesis 1**

Hypothesis 1 states that the mean score on a graphing skills test of a group of Algebra II students who have utilized the graphing calculator during instruction will be significantly higher than the mean score of a contrast group of Algebra II students who did not utilize the graphing calculator. The hypothesis was tested using ANCOVA with the TAAS mathematic score as the covariate and the post-test graphing skills test as the dependent variable. The observed means for the achievement items on the post-test, controlling for the TAAS mathematics scores, are presented as the adjusted means. ANCOVA tests the significance of the difference between the adjusted means. The adjusted means,
standard deviations, and results of the ANCOVA are presented in Table 5. The adjusted means on the achievement scores between the two groups revealed a \( p = .8686 \) as shown in Table 5, indicating no significant difference in achievement between the two groups after the treatment.

Table 5

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Adj. Mean</th>
<th>Std. Dev.</th>
<th>F Ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>86</td>
<td>66.72</td>
<td>17.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>84</td>
<td>66.25</td>
<td>20.03</td>
<td>.0275</td>
<td>.8686</td>
</tr>
</tbody>
</table>

**Hypothesis 2**

Hypothesis 2 states that the mean score on the mathematics attitude scale of the Algebra II students who utilized the graphing calculator will be significantly higher than the mean score on the mathematics attitude scale of the contrast group of Algebra II students who did not utilize the graphing calculator. The hypothesis was tested using ANCOVA where the pre-test score on the attitude scale was the covariate and the post-test score on the attitude scale was the dependent variable. The observed means for the attitude scale items on the post-test, controlling for
the pre-test, are presented as the adjusted means. ANCOVA tests the significance of the difference between the adjusted means. The adjusted means, standard deviations, and results of the ANCOVA are presented in Table 6. The adjusted means on the attitude scores between the two groups revealed a $p = .0001$ as shown in Table 6, indicating a significant difference in attitude between the two groups after the treatment.

Table 6

Comparison of the Posttreatment Attitude Toward Mathematics Scores with the Pretreatment Scores as the Covariate

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Adj. Mean</th>
<th>Std. Dev.</th>
<th>F Ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>86</td>
<td>7.4428</td>
<td>1.4209</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>84</td>
<td>6.2209</td>
<td>2.2421</td>
<td>18.4118</td>
<td>.0001</td>
</tr>
</tbody>
</table>

Hypothesis 3

Hypothesis 3 states that the mean score on the confidence in learning mathematics scale of the Algebra II students who utilized the graphing calculator will be significantly higher than the mean score on the confidence in learning mathematics scale of the contrast group of Algebra II students who did not utilize the graphing calculator. The hypothesis was tested using ANCOVA; the pre-test score on the confidence scale was the covariate and
the post-test score on the confidence scale was the dependent variable. The observed means for the confidence scale items on the post-test, controlling for the pre-test, are presented as the adjusted means. ANCOVA tests the significance of the difference between the adjusted means. The adjusted means, standard deviations, and results of the ANCOVA are presented in Table 7. The adjusted means on the confidence scores between the two groups revealed a $p = .0001$ as shown in Table 7, indicating a significant difference in confidence between the two groups after the treatment.

Table 7

**Comparison of the Posttreatment Confidence in Learning Mathematics Scores with the Pretreatment Scores as the Covariate**

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Adj. Mean</th>
<th>Std. Dev.</th>
<th>F Ratio</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>86</td>
<td>77.86</td>
<td>12.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>84</td>
<td>60.65</td>
<td>7.83</td>
<td>102.2087</td>
<td>.0001</td>
</tr>
</tbody>
</table>
The purpose of this study was to investigate the effectiveness of the graphing calculator to teach graphing skills in the conic sections unit of the Algebra II course. This study also investigated the effect of the use of the graphing calculator on students' attitude toward mathematics and confidence in learning mathematics.

Algebra II teachers and students from two closely matched high schools participated in the study. There were two experimental groups and two control groups at each high school. Each teacher taught both an experimental group and a control group and was provided staff development and extensive practice with graphing calculators during December and January prior to the beginning of the treatment as described in detail in Chapter 3. After the staff development, all teachers used graphing calculators in the experimental groups to teach the conic sections unit which encompassed approximately six weeks of instruction in February and March of 1994.

Three Algebra II teachers participated in the study. Two at High School A and one at High School B. At High School A one of each of the teacher’s classes was the experimental group and the other class was the control
group. At High School B two of the teacher's classes were the experimental group and the other two were the control group. Completing the study were 86 students in the experimental group and 84 students in the control group.

Data were collected three times during the study from all students in the experimental group and the control group. The pre-tests were given prior to the study, and the post-tests were given at the end of the study. The third source of data were the students' records where the researcher gathered Texas Assessment of Academic Skills (TAAS) mathematics scores.

Prior to the treatment, students in both the experimental group and the control group were given the pre-test Form A of the Purdue Master Attitude Scale and the pre-test Fennema-Sherman Confidence in Learning Mathematics Scale. Further, the researcher examined the students' cumulative files and used the TAAS mathematic scores as the covariate for achievement. These data enabled the researcher to determine any pre-existing conditions in the student groups.

Following the treatment, three tests were administered to each student in the experimental group and the control group. The post-tests completed by the students were the Test of Graphing Skills, Form B of the Purdue Master Attitude Scale, and Fennema-Sherman's Confidence in Learning Mathematics Scale. These tests were designed to investigate
any differences in achievement, attitude toward mathematics, and confidence in learning mathematics, respectively, by conducting statistical analyses to determine if a significant difference existed between the experimental group and the control group.

Summary of Findings

The hypotheses were examined using an Analysis of Covariance (ANCOVA) in which the raw scores were statistically analyzed by a computer to determine if there were measurable differences between the groups on achievement, attitude toward mathematics, and confidence in learning mathematics. In the ANCOVA, the TAAS mathematics score was the covariate for achievement with the Test of Graphing Skills as the dependent variable. In the ANCOVA on the remaining two variables, attitude toward mathematics and confidence in learning mathematics, the pre-tests were utilized as the covariates, and the post-tests were the dependent variables. The major findings resulting from the analysis of the statistical data in this study were the following:

1. No significant difference was found on the mean score on a graphing skills test of a group of Algebra II students who utilized the graphing calculator during instruction and a control group of Algebra II students who did not utilize the graphing calculator.
2. There was a significant difference (p-value = .0001) between the mean mathematics attitude scores for all of the students who were taught Algebra II utilizing the graphing calculator and a control group of students taught without the use of the graphing calculator.

3. There was a significant difference (p-value = .0001) between the mean score on the confidence in learning mathematics scale of all of the students taught Algebra II using the graphing calculator and a control group of students taught without the use of the graphing calculator.

Conclusions

Although there was not a significant difference in achievement between the experimental group and the control group, the experimental group had a higher mean score than the control group, leading the researcher to believe if the duration of the experiment was extended perhaps achievement would be positively impacted. Just such a result was reported by Lynch, et. al. (1989) in which graphing calculators had statistically significant positive results on student's achievement when implemented in Algebra over an entire school year. According to the Texas Education Agency (TEA) mandate dated September 29, 1993, districts must provide students with these graphing calculators by the 1995-1996 school year. Further, the National Council of Teachers of Mathematics (NCTM) standards expect each classroom to be equipped with this technology (1989).
addition, the new Texas Essential Elements (1991) make repeated references to graphing utilities in the Algebra II essential elements. With this increasing pressure to integrate the graphing calculator into mathematics instruction, perhaps this research of extended duration can be conducted in the very near future. Lastly, Kennedy & Chavkin (1992/1993) showed that statistically significant correlations were noted between student attitude and the use of graphing calculators with achievement. Therefore, with the results reported in this study, related to the graphing calculator’s positive effects on attitude, perhaps positive achievement effects would follow over the long term.

In addition, the pretreatment analysis shown in Table 2 indicated that prior to the beginning of the study the mean scores of the experimental group were lower than the mean scores of the control group in mathematics achievement. In fact, this difference was close to being statistically significant. However, after the treatment, the experimental group had a higher mean score on achievement than the control group. This leads the researcher to believe that with true randomization or if a more powerful covariate were utilized then perhaps the resulting difference in achievement scores would be statistically significant.

The statistically significant difference in attitude between the experimental group and the control group supports previous research referred to in Chapter 2 in
several ways. First, previous research showed that using hands-on learning materials to match students' learning styles produced a significant gain in attitude toward mathematics (Bryant, 1990; Angell, 1993). In addition, according to Demana & Waits (1990c), students lose their negative attitude toward mathematics with the graphing calculator. Further, this study supported the results of graphing calculator research conducted in precalculus and trigonometry in which positive gains in attitude toward mathematics were found (Rich, 1991; Army, 1992).

Graphing calculators enable students to gain more confidence with real world problems (Demana & Waits, 1990c). Confidence in learning mathematics literature were confirmed by this study. There were two previous studies using graphing calculators in which positive gains in confidence were found. One study used the graphing calculator to teach an introduction to calculus showed a dramatic increase in confidence in students' abilities to solve real world problems (McClendon, 1992). In a second study graphing calculators were used to teach pre-calculus; a positive gain in confidence in learning mathematics was reported (Durham, 1991).

Implications

Therefore, this study lends itself to the same premise as the review of the literature in Chapter 2. Namely, that attitude and confidence can be enhanced with hands-on
methods of instruction. The graphing calculator is one such powerful hands-on method of instruction that can be utilized to improve attitude and confidence in learning in the mathematics classroom. As teachers begin to implement graphing calculators into their mathematics instruction, greater increases in mathematics attitude and improved confidence in learning mathematics will also result.

This implies that we probably addressed the 50% of the student population who have preferred learning styles favoring visual experience over auditory with the graphing calculator thus improving their attitude toward mathematics (Duren 1990/1991; West, 1991). Thus, it would be extremely important to implement these graphing calculators into all mathematics classrooms in order to continue to address the needs of the majority of the students.

Since students are being turned off to mathematics while never having had the opportunity to explore its beauties and intricacies nor to develop their own senses of its importance and applicability to their lives; graphing calculators offer a genuine alternative to existing practices for teaching mathematics. Thus, based upon the positive results of this study, students seemed to enjoy learning mathematics and began to explore its pleasures with the graphing calculator. Therefore, this implies that students will be more motivated to learn mathematics. Perhaps achievement will also be impacted which is one of

Furthermore, the National Council of Teachers of Mathematics (NCTM) advocate more positive attitudes toward mathematics as well as the valuing of mathematics as primary goals in high school mathematics instruction (1989). These improved attitudes toward mathematics may result in students making choices to enroll in more mathematics courses in high school. This increase in mathematics background could lead more students to continue to enroll in more mathematics courses in their post-secondary education and as a result students would become more mathematically literate. This, in turn, would enable students to participate fully in our advanced technological society after they finish their college education. According to the Secretary’s Commission on Achieving Necessary Skills report entitled *What Work Requires of Schools: A SCANS Report for AMERICA 2000* (Packer, 1991) this should be a primary goal of our high school curriculum.

**Recommendations for Further Research**

Since the graphing calculator clearly impacted students’ attitude and confidence over a relatively short time span, this researcher recommends that graphing calculators be implemented throughout the high school mathematics curriculum because there exists evidence that
supports the fact that increased positive attitudes and confidence toward mathematics will also increase achievement (Kennedy & Chavkin, 1992/1993). It would also be appropriate to begin integrating this technology into the junior high schools as well to improve students' attitudes towards mathematics and confidence in learning mathematics prior to their entry into high school.

Findings of this study suggest the following further research:

1. Increase the period of study to a full school year rather than six weeks to allow students to become completely familiar with the graphing calculator.

2. Another study might extend the research to other units in Algebra II besides just the conic sections unit.

3. Examine whether the graphing calculator is more beneficial for low achieving students than for high achievers.

4. Examine whether the graphing calculator is more beneficial for females than for males.

5. Another study might use graphing calculators in other mathematics classes other than Algebra II.

6. Examine the effect of the graphing calculator on the achievement, attitude, and confidence of junior high school mathematics students.
7. Another study might solely focus on the most effective staff development to utilize when implementing the graphing calculator into instruction.
APPENDIX 1

CONSENT FORMS
Dear Parents:

I will be conducting a research project designed to study the effect of graphing calculators on the instruction of the Conic Sections Unit in Algebra II. I request permission for your child to participate. The study consists of using graphing calculators while learning the conic sections. Each student will be provided with a graphing calculator to use during the instructional period. Since technology is such an integral part of our society this will enable your child to become familiar with the graphing calculator, that colleges are using, in their mathematics instruction.

Each child will be asked to take a pre-test and post-test on the conic sections unit as well as on their attitude toward mathematics and confidence in doing mathematics. In addition, I will need to look at the school’s records in order to obtain your child’s mathematics scores on the Texas Assessment of Academic Skills. Each child will be referred to with a coding system in order to provide complete confidentiality.

Your decision whether or not to allow your child to participate will in no way affect your child’s standing in his or her class/school. Furthermore, your child’s participation in this study is voluntary. Your child may discontinue the study at any time without penalty or prejudice. At the conclusion of the study, a summary of group results will be made available to all interested parents and teachers. Should you have any questions or desire further information, please call me at 214-617-8704. Thank you in advance for your cooperation and support.

Sincerely,

Beverly Scott

THIS PROJECT HAS BEEN REVIEWED BY THE UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS.

(PHONE: 817-565-3940)

***********************************************

Please indicate whether or not you wish to have your child participate in this project, by checking a statement below and returning this letter to your child’s teacher as quickly as possible.

I do grant permission for my child,__________ to participate in this project.
I do not grant permission for my child,_________ to participate.

Parent/Guardian’s Signature
I, ________________________________, agree to participate in a study of the effectiveness of the graphing calculator at High School in Independent School District. I understand that the purpose of the study is to improve the instruction of mathematics through the use of the graphing calculator.

I understand that my participation is voluntary and that I may withdraw at any time. I understand that there is no risk or discomfort directly involved with this study. I understand that if I choose to participate, I will be expected to 1) take a conic section achievement test at the beginning of the study and at the end of the study; 2) take an attitude toward mathematics survey at the beginning of the study and at the end of the study; and 3) take a confidence in learning mathematics survey at the beginning of the study and at the end of the study.

I have been informed that any information obtained in this study will be recorded with a code rather than with my name. The researcher will not have a record which identifies me as an individual. Under this condition, I agree that any information obtained in this study may be used in any way thought best for publication or education.

If I have any questions, I should contact the researcher, Beverly Scott, at 214-875-9011 (work) or 214-617-8704 (home).

__________________________   __________________________
(Date)                      (Signature of Participating Student)

__________________________   __________________________
(Date)                      (Investigator)

THIS PROJECT HAS BEEN REVIEWED BY THE UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS.
Informed Consent for Teacher Involvement  
in the Use of Graphing Calculators at  
High School  

I, __________________________, agree to participate in a study of the effectiveness of the graphing calculator at High School in Independent School District. I understand that the purpose of the study is to improve the instruction of mathematics through the use of the graphing calculator.

I understand that my participation is voluntary and that I may withdraw at any time. I understand that there is no risk or discomfort directly involved with this study. I understand that if I choose to participate, I will be expected to 1) attend a one day training session on graphing calculators; 2) attend two after-school follow-up sessions of approximately 1 and 1/2 hours each; 3) administer to my Algebra II students a test of graphing skills as a pre-test and post-test of their understanding of the graphs of conic sections; 4) administer to my Algebra II students a pre-test and post-test of their attitudes towards mathematics; and 5) administer to my Algebra II students a pre-test and post-test of their confidence in learning mathematics.

I have been informed that any information obtained in this study will be recorded with a code rather than with my name. The researcher will not have a record which identifies me as an individual. Under this condition, I agree that any information obtained in this study may be used in any way thought best for publication or education.

If I have any questions, I should contact the researcher, Beverly Scott, at 214-875-9011 (work) or 214-617-8704 (home).

(Date) __________________________ (Signature of Participating Teacher)
(Date) __________________________ (Investigator)

THIS PROJECT HAS BEEN REVIEWED BY THE UNIVERSITY OF NORTH TEXAS COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS.
APPENDIX 2

TEXAS EDUCATION AGENCY’S

ESSENTIAL ELEMENTS FOR ALGEBRA II
The essential elements that follow delineate the content that must be taught in all of the Algebra II classrooms in Texas school districts. These essential elements establish what must be taught in the state curriculum. The essential elements were mandated in 1981 when the 67th Texas legislature passed House Bill 246. The State Board rules for implementing this law are contained in Title 19, Chapter 75 of the Texas Administration Code.

Algebra II (1 unit). Algebra II shall include the following essential elements:
(1) Development of mathematical structure. The student shall be provided opportunities to:

(A) compare and contrast the real number system and its various subsystems in terms of structural characteristics;

(B) investigate examples and nonexamples of fields using the real number system and its various finite and infinite subsystems; and

(C) develop the complex number systems and its operations.

(2) Quadratic functions. The student shall be provided opportunities to:

(A) solve quadratic equations by completing the square;

(B) develop and apply the quadratic formula;

(C) find a quadratic equation given its roots;

(D) explore the effects of simple parameter changes on the graph of a quadratic function, using computer graphing techniques where appropriate;

(E) use characteristics of a quadratic function to sketch the related curve;

(F) determine the equation of quadratic functions from their graphs; and

(G) use quadratic functions as models in real-world problem situations.

(3) Quadratic relations. The student shall be provided opportunities to:

(A) explore the graphs of algebraic representations of conic sections and make generalizations that allow classification of these algebraic representations as circles, ellipses, hyperbolas, or parabolas, using calculators or computers where appropriate;

(B) verify graphs of conic sections using computer graphing techniques where appropriate;
(C) use characteristics of conic sections to sketch the related curves;

(D) determine equations of conic sections from their graphs; and

(E) use quadratic relations as models in real-world problem situations.

(4) Systems of equations. The student shall be provided opportunities to:

(A) use the linear combination (addition-subtraction) method to solve systems of three linear equations in three variables;

(B) use augmented matrices by hand or by computer to solve two- or three-variable linear systems;

(C) apply linear programming techniques to model and solve real-world situations, using the computer or calculator, where appropriate; and

(D) solve quadratic-quadratic and quadratic-linear systems, and confirm the solution by computer graphing techniques.

(5) Numerical methods and higher degree polynomials. The student shall be provided opportunities to:

(A) use successive approximations on the calculator or computer to solve higher degree equations;

(B) apply synthetic substitution to find functional values of higher degree polynomials;

(C) use the Fundamental Theorem of Algebra and the Factor Theorem to factor higher degree polynomials;

(D) graph higher degree polynomial functions using computer graphing techniques;

(E) solve higher degree polynomial equations using computer graphing techniques; and

(F) use an iterative process (algebraic or
geometric) to approximate irrational roots of higher degree functions.

(6) Exponential and logarithmic functions. The student shall be provided opportunities to:

(A) investigate the concept of nth root and convert between exponential and radical forms of an expression;

(B) extend the properties of exponents to include rational exponents;

(C) investigate exponential functions and their inverses to develop the definition of logarithm;

(D) explore the graphs of exponential and logarithmic functions using computer graphing techniques;

(E) convert between logarithmic and exponential forms of equation;

(F) apply properties of logarithms to solve equations; and

(G) apply logarithmic and exponential functions in problem situations using the computer or calculator.

(7) Rational algebraic functions. The student shall be provided opportunities to:

(A) simplify complex fractions;

(B) graph rational algebraic functions (using computer graphing techniques where appropriate) to develop an intuitive understanding of the concept of limit; and

(C) use direct and inverse variation functions as models to make predictions in real-world situations.

(8) Sequences and series. The student shall be provided opportunities to:

(A) investigate patterns in given sequences and use the patterns or recursive or generator formulas to find additional terms;
(B) investigate and graph geometric and arithmetic sequences;

(C) find the nth partial sum of geometric or arithmetic series and find n given the nth term or partial sum;

(D) investigate convergent geometric series;

(E) use sequences and series as models in real-world problem situations;

(F) use the Binomial Theorem to expand powers of binomial expressions; and

(G) solve enumeration problems involving permutations and combinations.

(9) Data handling and analysis. The students shall be provided opportunities to:

(A) recognize the importance of unbiased sampling and valid reasoning in statistical arguments;

(B) select an appropriate sampling method for a given real-world problem situation;

(C) interpret probabilities relative to the normal distribution;

(D) design a simple statistical experiment to test a hypothesis generated by a real-world problem situation and interpret the results; and

(E) use computer simulation methods to represent and solve problem situations involving uncertainty.
APPENDIX 3

TEST OF GRAPHING SKILLS

PURDUE MASTER ATTITUDE SCALE

CONFIDENCE IN LEARNING MATHEMATICS SCALE
Instructions for taking the Test of Graphing Skills.

1. This test is designed to test your knowledge of graphing skills and concepts related to graphing conic sections.

2. There is a time limit to the test. Please take no more than 25 minutes to complete the test. That does not permit time to graph each equation on the test. Use what you know about the relationships between the coefficients in the standard form of the conic section to determine the correct answer. If you have no idea, try to eliminate those answers that are not correct and then select the most appropriate answer of those left.

3. Please mark your answer on the scantron provided and be sure to put your student code number on the scantron. You may write on the test booklet.

4. Your student code number will be an eight-digit code: the last four digits of your phone number followed by the two digits of your birth month (01-12) followed by the two digits of your day of birth. For instance, if you were the following person,

   Susie Student
   Phone Number: 348-2345
   Birthday: April 3, 1975

   Code: 2345-04-03

Test of Graphing Skills

1. Which of the following equations corresponds to the given graph?

   a) \( x^2 - y - 1 = 0 \)
   b) \( x^2 - y + 1 = 0 \)
   c) \( x^2 + y - 1 = 0 \)
   d) \( x^2 + y + 1 = 0 \)

2. Given the special case of the general formula \((Ax^2 + Bxy + Cy^2 + Dx + Ey + F)\) in which \(B=0, C=0, D=0, E=1\) such that \(Ax^2 + y + F = 0\), as \([A]\) becomes larger, the corresponding graph becomes _________.
   a) wider  b) narrower  c) an unchanged shape

3. Which of the following describes the graph of the equation \(6x^2 - 24x - y + 18 = 0\) ?
   a) opens down and crosses the x-axis at (-3,0) and (-1,0)
   b) opens up and crosses the x-axis at (1,0) and (3,0)
   c) opens down and crosses the x-axis at (1,0) and (3,0)
   d) opens up and crosses the x-axis at (-3,0) and (-1,0)

4. Which of the following represents the graph of the equation \(x^2 + y = 0\) ?
   a) 
   b) 
   c) 
   d)
5. Which of the following represents the graph of the equation $y^2 = x$?

a) 
\[ \begin{array}{c}
\text{y} \\
\text{x}
\end{array} \]

b) 
\[ \begin{array}{c}
\text{y} \\
\text{x}
\end{array} \]

c) 
\[ \begin{array}{c}
\text{y} \\
\text{x}
\end{array} \]

d) 
\[ \begin{array}{c}
\text{y} \\
\text{x}
\end{array} \]

6. The graph of the equation $x^2 + y^2 - 14x - 10y - 9 = 0$ would be a ________.

a) circle  b) parabola  c) ellipse  d) hyperbola

7. The graph of the equation $4x^2 + 9y^2 - 25 = 0$ would be a ________.

a) circle  b) parabola  c) ellipse  d) hyperbola

8. Which of the following represents the graph of the equation $9x^2 + 25y^2 - 225 = 0$?

a) 
\[ \begin{array}{c}
\text{y} \\
\text{x}
\end{array} \]

b) 
\[ \begin{array}{c}
\text{y} \\
\text{x}
\end{array} \]

c) 
\[ \begin{array}{c}
\text{y} \\
\text{x}
\end{array} \]

d) 
\[ \begin{array}{c}
\text{y} \\
\text{x}
\end{array} \]
9. Which of the following equations corresponds to the given graph?

- a) \( x^2 - y + 4 = 0 \)
- b) \( x^2 + y + 4 = 0 \)
- c) \( x^2 - y - 4 = 0 \)
- d) \( x^2 + y - 4 = 0 \)

10. Which of the following represents the graph of the equation \( 25x^2 + 9y^2 - 225 = 0 \)?

- a)
- b)
- c)
- d)

11. Which of the following equations corresponds to the given graph?

- a) \( x^2 + y^2 - 36 = 0 \)
- b) \(-x^2 + 9y^2 = 36 = 0 \)
- c) \( x^2 - 9y^2 = 36 = 0 \)
- d) \( x^2 + 9y^2 = 36 = 0 \)
12. Which of the following represents the graph of the equation $25x^2 - 9y^2 - 225 = 0$?

a)  

b)  

c)  

d)  

13. Given the general equation

$$Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0$$

if $A = C$ and $B = 0$, then the graph is a/n______. 

a) circle  b) parabola  c) ellipse  d) hyperbola

14. Which of the following represents the graph of the equation $-25x^2 + 9y^2 - 225 = 0$?

a)  

b)  

c)  

d)  

15. Given the general equation

$$Ax^2 + Bxy + Cy^2 + Dx + Ey + F = 0,$$

if $A$ is not equal to $C$, $A$ and $C$ have the same sign, and $F = 0$, then the graph is a/n______. 

a) circle  b) parabola  c) ellipse  d) hyperbola
APPENDIX 4

CONIC SECTIONS LESSON PLANS
**Have student’s and parent’s permission forms signed.
**Administer all Pre-tests to students.

Parabola Chapter Prior to Conic Sections Chapter

Suggested Assignments

Conic Sections Chapter


Suggested Activities

Circles

Day 1  Notes
Lesson #1  1-21 odd
Quiz #1 at end of this lesson

Ellipses

Day 2  Quiz #2
Notes
Lesson #2  1-19 odd

Day 3  Quiz #3
Lesson #3  2-20 even

Day 4  Quiz #4
Lesson #4  21-31 all

Day 5  Circles and Ellipse Test

Properties of Quadratic Equations

Day 6  Quiz #5
Lesson #5  1-16 all

Parabolas

Day 7  Quiz #6
Notes
Lesson #6  1-13 odd

Day 8  Quiz #7
Lesson #7  2-14 even

Day 9  Quiz #8
Lesson #8  15-25 all
Day 10  Parabolas Test

Hyperbolas

Day 11  Notes
Lesson #9  1-17 odd

Day 12  Quiz #9
Lesson #10  2-18 even

Day 13  Quiz #10
Lesson #11  19-28 all

Rectangular Hyperbolas

Day 14  Notes
Lesson #12  1-5 all

Quadratic Systems

Day 15  Quiz #11
Notes
Lesson #13  1-11 odd

Day 16  Quiz #12
Lesson #14  2-12 evens

Day 17  Review of Circles

Day 18  Review of Ellipses

Day 19  Review of Parabolas

Day 20  Review of Hyperbolas

Day 21  Review of Conics

Day 22  Test Over Conics

***Administer all Post-tests to Students
Circles

A circle is a locus of points in a plane, a given distance from a given point.

The locus is a set of points and only those points that satisfy a given condition.

The center is the given point.

Equations

General Form

\[ Ax^2 + Ay^2 + Dx + Ey + F = 0; \quad A = 0 \]

Standard Form

\[ (x-h)^2 + (y-k)^2 = r^2 \]

(h,k) is the center
r is the radius

Labeling

1. x and y axes
2. center; \( C(x,y) \)
3. 2 points horizontally on either side of the center
4. 2 points vertically on either side of the center
5. radius
Oral Exercises

Identify each of the following equations as a line, a circle, or none.

1. \(x^2 + y^2 - 4x - 6y + 4 = 0\)
2. \(y - 5 = -2(x + 1)\)
3. \(2x + 5y = -6\)
4. \(x^3 - 4x^2 + x + 6 = y\)
5. \((x - 5)^2 + (y + 2)^2 = 27\)
6. \(y = (x - 1)^3 + 1\)
7. \(y = 1/2x + 2\)
8. \((x + 2)^2 + (y - 4)^2 = 9\)
9. \(3x^2 + 3y^2 + 2x - 4y = 0\)
10. \(y = -2/3x + 6\)

Written Exercises

Write an equation of the form \((x - h)^2 + (y - k)^2 = r^2\) for the circle with the given center and radius.

1. \(C (1, 2); r = 3\)
2. \(C (-2, 3); r = 4\)
3. \(C (-2, 0); r = 1\)
4. \(C (-1, -1); r = 1/2\)
5. \(C (0, 2); r = 3\)
6. \(C (2, -1); r = 2\)

Give the center and radius of the circle having the given equation.

7. \((x - 3)^2 + (y - 1)^2 = 4\)
8. \((x + 2)^2 + (y - 1)^2 = 9\)
9. \((x + 1)^2 + (y + 1)^2 = 1\)
10. \((x + 3)^2 + y^2 = 1\)
11. \(x^2 + (y - 2)^2 = 1/4\)
12. \((x - 3)^2 + (y - 2)^2 = 5\)

Find the center and radius, then graph the following circles. If the equation has no graph, so state.

13. \(x^2 + y^2 = 16\)
14. \(x^2 + y^2 + 4 = 0\)
15. \(x^2 + y^2 - 4x = 0\)
16. \(x^2 + y^2 = 2y\)
17. \(x^2 + y^2 - 10x - 4y + 13 = 0\)
18. \(x^2 + y^2 + 4x - 8y + 11 = 0\)
19. \(x^2 + y^2 + 6x - 4y - 3 = 0\)
20. \(x^2 + y^2 - 4x + 2y + 6 = 0\)
21. \(x^2 + y^2 + 2x - 6y = 0\)
22. \(2x^2 + 2y^2 - 6x - 2y + 3 = 0\)

Write an equation of the circle having the given properties.

23. Center \((2, 0)\); passes through the origin.
24. Center \((0, 3)\); passes through \((0, 6)\).
25. Center on the line \(y = 2\); tangent to \(x\)-axis at \((3, 0)\).
26. Center on the line \(x + y = 6\); tangent to the \(x\)-axis at \((2, 0)\).
27. A diameter of the circle has endpoints \((-2, 3)\) and \((6, 5)\).
Identify each of the following equations as a line, a circle, or none.

1. $3x + 7y = -4$
2. $(x + 1)^2 + (y - 4)^2 = 49$
3. $x^2 + y^2 - 2x + 8y + 1 = 0$
4. $4x^2 + 4y^2 - 8x + 16y = 0$
5. $y = (x - 1)^3 + 8$
6. $y = -1/3x + 4$
7. $x^2 + (y - 3)^2 = 0$
8. $y - 1 = -1(x + 4)$
9. $x + y = 1$
10. $x^3 + y^3 = 3$
Circles and Ellipses Test

Identify each of the following equations as a line, a circle, an ellipse, or none. (2 points each)

1. \(x^2 + y^2 = 51\)
2. \(4x^2 + 3y^2 = 48\)
3. \(9x^2 + 9y^2 = 900\)
4. \(7x^2 + 2y^2 - 3x + 4y - 11 = 0\)
5. \(x + y = 11\)
6. \(\frac{(x + 1)^2}{16} + \frac{(y - 2)^2}{24} = 1\)
7. \(\frac{x^2}{9} + \frac{y^2}{9} = 1\)
8. \(y = -\frac{1}{3}x + 2\)
9. \((x - 4)^2 + (y + 1)^2 = 25\)
10. \(y = -lx^2\)

Fill in the blank. (3 points each)

11. A(n) ______ is a locus of points in a plane such that the sum of the distances from two fixed points to a point on the curve is constant.

12. A(n) ______ is a locus of points in a plane a given distance from a given point.

Write the equation for a circle with the given center and radius. (4 points each)

13. \(C(2, -3); r = 4\)
14. \(C(0, 0); r = \frac{1}{3}\)
15. \(C(-4, -1); r = 1\)

Find the center and radius of each circle. (4 points each)
Give the x and y-intercepts of each ellipse and state whether the major axis is horizontal or vertical. (4 points each)

x-intercept 19. $x^2 + \frac{y^2}{1} = \frac{36}{36}$
y-intercepts
major axis

x-intercept 20. $9x^2 + 4y^2 = 36$
y-intercept
major axis

Write the equation for each ellipse with center (0, 0). (4 points each)

x-intercept 21. $x + 3$
y-intercept $\pm 5$

foci $(\pm 8, 0)$
x-intercept $\pm 10$

foci $(0, \pm 3)$
The length of the major axis is 10.
Graph each of the following. (10 points each)

24. \((x - 1)^2 + (y + 2)^2 = 49\)

25. \(\frac{x^2}{36} + \frac{y^2}{100} = 1\)

26. \(9x^2 + 16y^2 = 144\)
REFERENCES


solving ability and attitude toward mathematics.


Cook, P. J. (1988). The effects of an instructional unit utilizing logo and the computer on achievement in geometry and attitude toward mathematics of selected high school general mathematics students. Dissertation Abstracts International, 49, 05A.


Eckert, P. & Miller, J. (1989). Data analysis using a handheld graphing calculator. In *Algebra teachers are the_


classroom: Graphing packages...The #1 headache
reliever. The Computing Teacher, 16(2), 34-35 & 56.

software upon mathematical problem-solving ability and
attitudes toward mathematics. Dissertation Abstracts
International, 50, 12A.

Kaput, J.J. (1986). Information technology and mathematics:
Opening new representational windows. The Journal of
Mathematical Behavior, 5, 187-207.

with the HP-28C. Computer Algebra Systems in Education
Newsletter, 4, 19-21.

technology brings algebra to all. Educational
Leadership, 50(4), 24-27.

mathematics: A back-to-the-basics approach.
International Journal of Mathematical Education
in Science and Technology, 11, 323-325.

Konvalina, J. (1981). An experimental study in basic
mathematics concerning self-assessment, achievement,
and confidence. International Journal of Mathematical
Education in Science and Technology, 12, 271-277.

attitude toward mathematics and active participation in
the mathematics class. Dissertation Abstracts International, 50, 01A.


Loop, S. (1992). The effect of teacher training in the use of computer graphing software on the achievement of
algebra II students. *Dissertation Abstracts International*, 52, 09A.


Rubenstein, R. (1992). Teaching the line of best fit with a graphing calculator. In J. T. Fey & C. R. Hirsch (Eds.), *Calculators in mathematics education*, (pp. 101-


remediation on the achievement and attitudes of low-achieving junior high school students. *Dissertation Abstracts International*, 53, 03A.


