AN ANALYSIS OF THE ATTITUDES OF HIGH SCHOOL STUDENTS TOWARD MATHEMATICS AFTER INSTITUTING THE USE OF GRAPHING CALCULATORS

A RESEARCH PROPOSAL

Submitted to the Department of Teacher Education,
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Master of Science in Education

by

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DEDICATION

This Project is dedicated to

my husband, Michael,

and to my children, John and Ellen,

for their support, sacrifices, and love.

I dedicate this work as well to

my parents, Harold and Jane Lockwood,

for their love

and everything they have given to me.

CHAPTER I

INTRODUCTION

Purpose for the Study

An enduring concern in today's schools is how well students are mastering mathematics. A tremendous challenge facing mathematics educators is to attract students to the subject and develop their mathematical abilities. Increasingly, the focus is on how mathematics is being taught, and more specifically, ways that teaching mathematics can be enhanced through the use of technology (Usiskin, 1993). Technological innovation, an evolving human endeavor, continues to receive a great deal of emphasis. Calculators and computers seem naturally to lend themselves to mathematics. However, as with most topics in education, the use of technology in the classroom has its critics as well as its advocates (Saxon, 1988).

A relatively new component of the technological package is the graphing calculator. It was introduced in the late 1980's and early 1990's as a powerful, hand-held, programmable computer with scientific calculator capabilities (West, 1991). Although the use of any calculators in the mathematics classroom remains controversial, the introduction of the graphing calculator has generated more discussion and research among mathematics educators than any technological innovation of the past several years (Dick & Dunham, 1994). Undoubtedly, the graphing calculator has impacted greatly on mathematics classrooms.

In 1989 the National Council of Teachers of Mathematics (NCTM) published the *Curriculum and Evaluation Standards for School Mathematics,* which set five general goals for students: (1) to learn to value mathematics, (2) to have confidence in their ability, (3) to become mathematical problem solvers, (4) to learn to communicate mathematically, and (5) to reason mathematically. The NCTM strongly advocated that all students have access to calculators (Curriculum and Evaluation Standards for School Mathematics, 1989). Many recently written textbooks reflect these goals, and facilitate integrating graphing calculator use into the mathematics curriculum.

In 1993 the researcher was hired to teach with the mandate to help bring the school mathematics curriculum into the 1990's and integrate technology into the mathematics classroom. The directives included exploring technology options available for students, choosing the specific model of graphing calculator for adoption by the school, leading the in-service team to train teachers to use the graphing calculators, and investigating textbooks that would integrate this technology into the study of mathematics at all levels. The researcher participated in several workshops on the use of the graphing calculator. These have helped her build to a level of proficiency and confidence that has been found to be critical to implementing graphing calculators successfully into the classroom (Bitter & Hatfield, 1992).

In 1993 the researcher started to use graphing calculators in one calculus class of twenty-five students, and she observed many changes in her classroom. There appeared to be genuine enthusiasm for mathematics by these students, once they had become acclimated to their calculators. The researcher noted changes in classroom dynamics, and that different teaching methods, such as cooperative learning groups and mathematical explorations, seemed to be more successful than they had been before. The researcher decided to investigate if these observations were genuine and whether or not there was a real difference in her students' attitudes and perceptions toward calculators and mathematics.

For the 1994-95 school year the school in this study adopted the use of graphing calculators in all mathematics classes from entry-level through calculus. There appeared to be a dramatic impact on student attitudes toward mathematics and a revitalization of enthusiasm for learning mathematics. The researcher observed some difference between ninth grade students, who had never had high school mathematics previous to the introduction of graphing calculators, and twelfth grade students, who had three years of experience in high school mathematics without the calculators and now were required to use them.

The researcher chose to analyze the changes in student perceptions and attitudes toward mathematics after instituting the use of graphing calculators.

Statement of the Problem

The purpose of this study was to analyze the perceptions and attitudes of high school students toward mathematics after instituting the use of graphing calculators.

Research Questions

1. Is there a major difference in perceptions between ninth and twelfth grade students regarding the use of graphing calculators in mathematics?

2. Is there a major difference in the perceptions and degree of enthusiasm for mathematics between ninth and twelfth grade students after instituting the use of graphing calculators?

Assumptions

A Likert survey and a semantic differential were used to survey student attitudes and perceptions toward mathematics and the graphing calculator. Underlying the survey was the assumption that students answered the questions truthfully and thoughtfully.

It was assumed that the survey instruments were valid and measured student attitudes toward the use of graphing calculators in mathematics and their enthusiasm for mathematics after instituting the use of graphing calculators.

Limitations

One limitation of this study was that there was no pre-test possibility. The decision was made to require the use of graphing calculators in certain mathematics courses this school year and that eclipsed the opportunity to survey the students prior to the introduction of the calculators. Not having an opportunity for pre-testing precluded the use of more sophisticated experimental designs.

A second limitation was that the entire population was not treated, since not all students were required to purchase graphing calculators.

A third limitation was that although the sample size of approximately 150 students is ample, only one site was used in the study. The findings from this one site cannot be generalized to other samples at other sites. It is not known if the results would differ if additional students from other schools and school systems could be surveyed.

A fourth limitation was that students or their families had made an investment of approximately 85 to 90 dollars to purchase a graphing calculator. For most students this was a significant amount of money and there was concern that this expenditure could influence the survey responses.

A final limitation was that students were well aware of the enthusiasm that the mathematics faculty has for this new technology, and some students may try to give survey responses they think would please the researcher. It was hoped that by keeping the survey responses anonymous this limitation would be minimized.

Definition of Terms

Graphing calculators are hand-held scientific calculators that are also programmable computers with the built-in capability to handle sophisticated mathematical algorithms and to graph functions. They are also referred to as graphics calculators, graphing utilities, advanced calculators, super calculators, pocket computers, and programmable calculators.

Technology is the use of calculators and computers as tools used by students in the mathematics classroom.

Mathematics curriculum is the body of mathematics knowledge and the mathematics course of study taught in grades nine through twelve at the high school level.

Attitudes are a student's positive or negative feelings, impressions, and perceptions toward a particular subject as measured by the Likert-like survey instrument.

Student enthusiasm is the level of positive attitudes and perceptions as measured by the semantic differential.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

Throughout history, the introduction of any innovation, especially technological innovations, has had its share of supporters and detractors. The introduction of graphing calculators is no exception to that rule. The researcher has reviewed the literature on this subject, placing particular emphasis on studies done within the past five years, since that roughly coincides with the introduction of graphing calculator technology into high school and collegiate mathematics classrooms.

This research chapter has been divided into three categories. They are:

1. Use of Calculators in the Mathematics Classroom - the Debate,
2. Reasons for Using the Graphing Calculator, and
3. Student Attitudes Toward Mathematics.

Use of Calculators in the Mathematics Classroom - the Debate

There is a great deal of support for the use of all types of calculators in the mathematics classroom (Dessart & Hembree, 1986). In fact, the National Council of Teachers of Mathematics (NCTM) has not only supported but strongly advocated the use of calculators for all levels of mathematics instruction since the early 1980's. Indeed, the evidence of numerous studies and articles convinced Demana & Osbourne (1988) to state, "Concerned educators should now spend their energy on issues affecting how learners can best use the calculator rather than on whether the calculator should be used." (p. 2).

The graphing calculator is a technological extension of that recommendation. When the current "bible" for mathematics education was written, the *Curriculum and*

Evaluation Standards for School Mathematics, the underlying assumption for grades nine through twelve was that, "Scientific calculators with graphing capabilities will be available to all students at all times" (National Council of Teachers of Mathematics, 1989, p. 24). This NCTM recommendation was strongly advocated by Demana & Waits (1992a) who stated:

> Students should have access to graphing calculators at all times -- for work in class and for homework. Teachers of other subjects insist that their students use modern technological tools. Should mathematics teachers do less? Would you dig the foundation of your house with a pick and shovel if you had access to a backhoe? Students or their parents should be required to buy graphing calculators. They are the paper and pencil of the 1990's. (p. 94)

Emphasis should be placed on mathematics achievement in the mathematics classroom, and there is evidence that this achievement is enhanced through the use of calculators (Dessart & Hembree, 1986). An interesting outcome of adopting calculators in the classroom is the conclusion that mathematics should be taught differently when calculators are permitted (Bright, Lamphere, & Usnick, 1992). With the proper training, teachers can emphasize standard drill and practice exercises, and students can be encouraged to explore real world applications of mathematics at all levels. The use of calculators can enable elementary and middle school students to tackle more complex problems requiring long logical trains of thought at a younger age than traditionally thought possible (Usiskin, 1993).

Despite the strength of the recommendations on calculator use, there are some critics, particularly about its use in the elementary school classroom. Some educators think that students will not learn fundamental mathematics if they are allowed to use calculators at too early an age. Others hold to the opinion that students can learn more effectively with calculators and explore mathematical problems more fully. This controversy has divided educators, students, and parents into two camps, one for and one against the use of calculators in the classroom. Dick (1988) stated that, "the effect of calculator use on the development of basic skills has always been the major source of disagreement between the two sides" (p. 38). Saxon (1988) has been a particularly vocal critic of calculator use, and he wrote:

> Common sense tells us that if calculators are approved and made available too early, many capable students will resist doing the arduous paper-and-pencil practice that is necessary to develop the mental skills of arithmetic. Calculators should not be permitted until the first or second year of high school mathematics, by which time the students will have completed their instruction in arithmetic. (p.37)

Gardiner (1987) warned that "there are no technological fixes in mathematics education" (p.16). Dick (1988) refuted these arguments, stating that:

> "What was good enough for me should be good enough for them" should not be a rationale for the elementary school mathematics curriculum. Mechanically grinding through paper-and-pencil computations would not lend itself to insights about arithmetic any more than mechanically moving the beads on an abacus, manipulating a slide rule, or operating a calculator. (p.39)

Another reason that the controversy over the use of calculators in the mathematics classroom continues is, in part, because students are not permitted to use calculators on many standardized tests and mathematical competitions (Long, Osterlind, & Reyes, 1989; Reiter & Reiter, 1991). The National Council of Teachers of Mathematics recommends that calculators should be allowed on all tests (NCTM, 1989). Tests can be written to assess understanding of mathematics rather than skill in performing numerical manipulations. Many educators feel that students should not only be able to use a calculator, but to be able to decide when to use one (Kenelly, 1990). Testing remains a controversial but dynamic issue. As of March, 1994, students were permitted to use any four-function, scientific, or graphing calculators on the Preliminary Scholastic Aptitude Tests (PSATs) and the Scholastic Aptitude Tests (SATs), and beginning in 1995 they will be permitted on the Advanced Placement Calculus examinations (College Board, 1992).

While the debate over the use of any calculators in the mathematics classroom continues, important new technological advances in hand-held graphing calculators occurred in the late 1980's and early 1990's. Instead of being expensive, mathematical oddities reserved for engineering and mathematics professionals, the calculators became relatively inexpensive and accessible to most students. This has resulted in mathematics educators seriously studying reasons for using graphing calculators.

Reasons for Using Graphing Calculators

An important reason for using calculators is that the arrival of affordable, hand-held graphing calculators have given students access to technological tools previously available only within the narrow confines of a computer laboratory (Trotter, 1991; West, 1991). Demana & Waits (1992b) stated that:

> inexpensive, user-friendly graphing calculators serve as a vehicle to empower students through the use of technology today. They are computers with powerful, easy-to-use, built-in software. Furthermore, graphing calculators can be used at home, in study hall, and on school buses. (p.181).

Indeed, graphing calculators "provide the reality of mathematics classrooms where every student has tools only available on mainframe computers 20 years ago" (Dick, 1992a, p.1).

A second reason for using graphing calculators is that they allow students to be introduced to mathematical concepts and techniques that have been beyond the reach of the traditional curriculum. Students can be introduced to a different level of mathematics than was possible without calculators (Lichtenberg, 1988). Graphing calculators are an important tool to help students have "full access to courses rich in mathematical content" (Branca, Breedlove, & King, 1992). Burrill(1992) stated: "graphing calculators present a dramatic new challenge in teaching mathematics by changing the very nature of the problems important to mathematics and the methods used to investigate those problems" (p.15).

Another reason for using graphing calculators is that they can promote a more complete and deeper understanding of mathematical concepts (Demana, Schoen, & Waits, 1991; Branca, Breedlove, & King, 1992; Hansen, 1994; Horak, 1994). Graphing calculators can connect graphical, algebraic, and tabular representations of mathematical functions to help students develop a fuller understanding of their nature. The effective use of these calculators requires a high-level understanding of the mathematical concepts involved, and an ability, achieved through practice, to interpret the results (Dion, 1990; Hector, 1992). This point of view was stated succinctly by Vonder Embse (1992). He stated:

> The NCTM *Standards* expresses the new vision of mathematics instruction, K-12, which stresses problem solving, communication, reasoning, and mathematical connections throughout the curriculum. Multiline or graphing calculator technology can be the tool that helps students and teachers realize this new vision of school mathematics. (p.65)

An important reason for using graphing calculators is that they change the way students are taught mathematics, and more importantly, the way students learn mathematics (Demana & Waits, 1988; Mercer, 1992). Regular use of graphing calculators changes "not only what and how teachers teach, but what and how teachers test" (LaTorre, 1991, p.11). Many teachers have found that implementation of graphing calculators has significantly changed the dynamics of their classrooms. There is usually a shift away from teacher lectures to a climate with the teacher as a guide, helping students with investigations. Teachers may initially feel uncomfortable with a perceived lack of structure or control. Generally, students who use graphing calculators become more active in the classroom, do more group work, and are more heavily involved in investigations, explorations, and problem solving. This shift in classroom climate was summarized by Dick and Dunham (1994) who stated, "The mere presence of graphing technology cannot account for these results. Rather, the combination of technology and changes in curriculum and instruction must be examined." (p. 442)

The reasons for using graphing calculators are numerous, including allowing students access to inexpensive, user-friendly, portable technological computers; introducing students to higher levels of mathematics earlier; promoting a more complete understanding of mathematical concepts; and revitalizing and enhancing the way that mathematics is taught and learned. Perhaps the most significant reason for using graphing calculators is that they help to change student attitudes towards mathematics.

Student Attitudes Toward Mathematics

Research shows that there is a significant difference in student attitudes toward mathematics when they are allowed to use graphing calculators (LaTorre, 1991; Paden & Templeton, 1991). Hembree (1986) integrated the findings of seventy-nine research studies into a "meta-analysis" and concluded, "Students using calculators have better attitudes towards mathematics and better self-concepts in mathematics than students not using calculators. This statement applies across all grade and ability levels." (p.20)

Calculators are a valuable tool for affecting students' attitudes toward mathematics by building their confidence and self-esteem (Dessart & Hembree, 1986; Finley, 1992; Nichols & Taylor, 1994). This position was made by a study done by Branca, Breedlove, and King (1992), who stated, "Students will not learn mathematics if they refuse to try mathematics. Using calculators lets some students function confidently in difficult classes, despite previous negative experiences." (p.11)

Once again, the change in student attitudes towards mathematics can be attributable to more than simply allowing calculators to be used. Bitter and Hatfield (1992) found "that how a teacher integrates calculator use in his or her classroom is a critical factor in student achievement and attitude." (p. 201) A conventional lecture-and-practice teaching technique may seem easier initially, but a student-directed approach helps improve attitudes as students gradually develop confidence and initiative in mathematical problem solving (Fischer & Lynch, 1989).

This improvement in student attitude toward mathematics seems to extend to the testing situation as well. Permission to use calculators during testing seems to promote a more positive reaction towards mathematics tests. Students' attitudes toward calculators and confidence in their own ability to use them directly impact the students' performance on mathematics tests (Loyd & Munger, 1989; Hopkins, 1992). It appears that gender-related differences in mathematics test performance dissipate as well with graphing calculator use. Demana, Schoen, & Waits (1991) observed that "in college algebra classes requiring use of graphing calculators, gender-related differences in performance on graphing items were eliminated, whereas pretest performance on graphing items indicated that females performed at a lower level than males." (p.30)

Students with a positive attitude toward mathematics that they attribute directly to their use of graphing calculators generally make the decision to study more mathematics (Dick, 1992b). This is a very good outcome for advocates of mathematics, science, and technology.

In summary, while the use of graphing calculators is not the cure for all the ills in mathematics education, it can generally be interpreted as having a positive impact on mathematics. The researcher hoped to partially answer some primary, important questions, like those raised by Dick (1992). He stated:

1. How will symbolic-graphical calculators affect what students learn and how they learn mathematics?

2. How will symbolic-graphical calculators affect what teachers teach and how they teach mathematics?

3. How will symbolic-graphical calculators affect how both students and teachers perceive mathematics? (p.1)

The graphing calculator phenomenon is relatively recent, within the last five years. Not enough research has been done to enable a final verdict on their use in mathematics classrooms. However, both advocates and skeptics, and most especially this researcher, have a keen interest in what more studies will show about the impact of graphing calculator technology on teaching and learning mathematics.

CHAPTER III

PROCEDURE

Subjects

The subjects of this study were 144 students in grades nine and twelve who were enrolled in the same high school. There were 68 males and 76 females. The 76 ninth grade students were all 14 or 15 years old and were enrolled in Algebra I and Honors Algebra I classes. The 68 twelfth grade students were 17 or 18 years old and were enrolled in Pre-Calculus and Calculus classes. The students come from a variety of socio-economic backgrounds, but they were predominantly lower-middle to middle class. Many of the students work to help pay their own tuition of approximately $3,000 per year, and for most families at the school this tuition was a real financial sacrifice. Approximately 80 percent of the students go on to higher education. The majority of students live with two parents in the home, but in most cases both parents work full-time. A considerable number of students are in one parent households. Approximately 90 percent of the students are Roman Catholic.

Setting

School. The school chosen for this study was a private, coeducational high school in a Catholic Diocesan school system. Students were enrolled in grades nine through twelve. Approximately 500 students attend the school and there are about 35 faculty members. Over one-half of the professional staff hold advanced degrees. Twelve different mathematics courses are offered, and students are placed according to ability and achievement. The school requires two mathematics credits to graduate (although a proposal is pending to make it three credits), but the vast majority of the students take at least three years of mathematics courses and many students take four. A full collegepreparatory curriculum is taught, but the option of vocational or marketing education programs are offered as well. Class size average is about 25 students, and teachers typically teach six classes daily. There is a strong sense of commitment to helping students achieve their full potential in academic, social, co-curricular, and athletic programs.

Community. The school is located in an urban community on the west side of a large mid-western city. Students come from the surrounding urban and suburban areas. The neighborhood immediately surrounding the school is neat and well-kept, but there are signs of structural aging and impoverished city life within a one-half mile radius of the school. The two public high schools in the area have experienced problems with drugs, gangs and violence, and many see this particular school as an oasis within a somewhat troubled community.

Data Collection

Construction of the Data Collecting Instrument. The study was conducted through the use of two instruments. The first was a Likert-like survey about student perceptions and attitudes toward using graphing calculators in mathematics. The survey had written directions and then students were asked to list their grade in school, their gender, the mathematics class they were currently taking, and to note whether or not they owned a graphing calculator. This section was followed by a set of twenty-five statements that were pertinent to graphing calculator use in mathematics. One-half of the statements expressed an attitude that the researcher interpreted as favorable and one-half expressed an unfavorable attitude, and the statements were listed in random order to avoid response set (Ary, Jacobs & Razavieh, 1985). Responses were restricted to closed answers and measured on a modified Likert scale with four categories: Strongly Agree, Agree, Disagree, and Strongly Disagree (Fowler, 1988). The researcher believed that the students would be likely to simply circle the "undecided" choice if that option were made available. See Appendix A for a copy of the Likert scale survey used in this study.

The second data collection instrument was a semantic differential survey to determine student attitudes and the degree of enthusiasm towards mathematics. It had written directions followed by twenty bipolar evaluative adjective pairs about mathematics. Bipolar adjective pairs were chosen by referring to studies that have been done on the strength of particular adjective pairs, as well as by consulting a thesaurus (Osgood, Suci, & Tannebaum, 1957; Jenkins, Russell, & Suci, 1958). Responses to this survey were restricted to closed answers that were quantitative ratings made by indicating a choice on a five point scale that best represented their attitude (Gay, 1987). Adjective pairs were listed in both directions to minimize response set (Ary, Jacobs, & Razavieh, 1985). See Appendix B for a copy of the semantic differential survey used in this study.

Face validity was established by preparing sample items for the survey instruments and giving these items to the mathematics faculty members at the school used in the study as well as other schools. This panel of experts used the Delphi Technique to rank order the questionnaire items, and the results were tabulated to reach a group consensus (Isaac & Michael, 1981). Only the top ranking items were included in the actual surveys.

Content validity, the degree to which a test measures an intended content area, was established with a field test using additional subjects outside the study (Gay, 1987). These were tenth grade students at the same school used in the study instead of the ninth and twelfth graders chosen for the study. During the field test the researcher noted completion time, which was about fifteen minutes. After the subjects completed both survey instruments, the researcher asked if anything was unclear or vague, how easy the surveys were to understand, if the directions were clear, and for any suggestions or changes that they might have. These suggestions were incorporated into the study. The researcher also directed the subjects not to discuss the survey outside of the classroom. There was a four week period between the field test and the study.

Administration of the Data Collecting Instrument. All of the subjects in this study had owned their own graphing calculators at least six months. The students had received extensive instruction in their mathematics classes on the various functions of the calculator and how to effectively use them. The students use these calculators daily, both in their mathematics classes and at home for homework assignments.

The surveys were administered in mid-February after several months of extended calculator use and instruction. The surveys were administered to the respondents in a normal classroom setting , with seven different classes participating in the study. Directions were read aloud to each group. Only questions pertinent to the survey procedure were answered. Subjects then independently and anonymously completed the Likert scale survey. When everyone had completed the questionnaire, a student collected the survey sheets and shuffled them to randomize the order. Then the semantic differential survey instrument was administered using the same process. All classes were surveyed on the same day in order to minimize subjects influencing each other's responses. The researcher conducted all survey sessions personally.

The researcher distributed 153 questionnaires. Only the 144 respondents who owned a graphing calculator were included in the this study. This was a 94 per cent response rate. The remaining nine questionnaires were not included in this study because the students did not own graphing calculators. However, these students were given a survey in the classroom because it was the researcher's opinion that the results would be more valid if every student in a particular class filled out a survey so that the survey process was not perceived negatively.

CHAPTER IV

RESULTS

Presentation of the Results

Research Question 1

The Likert questionnaire was designed to answer the first research question, which was:

Is there a major difference in perceptions between ninth and twelfth grade students regarding the use of graphing calculators in mathematics?

After the survey instruments were completed by the subjects, the researcher calculated the mean response and the standard deviation for each of the twenty-five items on the questions. The response for each item ranged from 1 to 4 as follows: 4 = Strongly Agree, 3 = Agree, 2 = Disagree, and 1 = Strongly Disagree. The survey responses were divided into response groups in order to best answer the research question. The groups were: ninth grade females, ninth grade males, all ninth grade students, twelfth grade females, twelfth grade males, and all twelfth grade students.

Based on a scale from 1 to 4, the researcher determined that a response of 2.5 or higher for a positive statement would be considered as agreement, and a response of less than 2.5 would be considered as disagreement. The survey responses to the Likert questionnaire about student attitudes and perceptions toward mathematics are presented here in Tables 1 and 2:

TABLE 1

MEAN RESPONSES OF NINTH GRADE STUDENTS TO LIKERT QUESTIONNAIRE ITEMS

4=Strongly Agree 3=Agree 2=Disagree 1=Strongly Disagree

Questionnaire Item	Females N=33		Males N= 43		All N=76	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
1. You should not be allowed to **N** use a calculator in math tests.	1.45	.83	1.93	1.05	1.72	.99
2. Math is more boring when you **N** use a calculator.	1.55	.62	1.81	.66	1.70	.65
3. Calculators make math fun. **P**	3.12	.33	2.93	.77	3.01	.62
4. I will forget how to do math in **N** my head if I use a calculator.	1.61	.61	2.07	.85	1.87	.77
5. Math is easier if you use a **P** calculator to solve problems.	3.21	.65	3.47	.55	3.36	.60
6. Using a calculator is confusing. **N**	2.12	.65	2.05	.58	2.08	.61
7. I am more confident when I use **P** a calculator to do math.	3.36	.60	3.23	.75	3.29	.69
8. I make more mistakes when **N** I use a calculator.	1.70	.53	1.63	.58	1.66	.56
9. I try harder in math when I **P** use a calculator.	2.55	.79	2.56	.85	2.59	.82
10. Learning how to use a **N** calculator is difficult.	2.30	.88	2.37	.82	2.34	.84
11. My calculator was a waste **N** of money.	1.42	.61	1.23	.71	1.45	.64

Questionnaire Item	Females N=33		Males N=43		All N=76	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
12. I understand math better when N I use a paper and pencil instead of a calculator.	2.39	.66	2.47	.70	2.44	.65
13. If given a choice, I would not N choose a math class that makes you use a calculator.	1.73	.63	2.00	.87	1.88	.78
14. My math grades are better when P I use a calculator.	3.10	.63	3.05	.69	3.07	.66
15. I do my math homework more P carefully when I use a calculator.	3.06	.75	2.81	.76	2.92	.57
16. I have never liked calculators. N	1.58	.56	1.74	.58	1.67	.57
17. I do better in math when I use P a calculator.	3.06	.70	3.09	.68	3.08	.69
18. I prefer working word problems P with a calculator.	2.56	.79	2.53	.80	2.55	.79
19. Working with calculators is N boring.	1.82	.46	1.95	.69	1.89	.60
20. I am a stronger math student P since I use my calculator.	2.85	.67	2.86	.83	2.86	.76
21. Everyone taking math should P have a calculator.	3.33	.60	3.05	.69	3.17	.66
22. My calculator was expensive P but worth the money.	3.33	.60	3.19	.73	3.25	.68
23. I rely too much on my N calculator.	1.94	.50	2.33	.78	2.16	.69
24. It is important that everyone P learn to use a calculator.	3.33	.48	3.02	.60	3.16	.57
25. I am going to take more math P classes than I had planned to since I can use my calculator.	2.36	.29	2.35	.80	2.36	.69

TABLE 2

MEAN RESPONSES OF TWELFTH GRADERS TO LIKERT QUESTIONNAIRE ITEMS

4=Strongly Agree 3=Agree 2 = Disagree 1=Strongly Disagree

Questionnaire Item	Females N=43		Males N=25		All N=68	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
1. You should not be allowed to use a calculator in math tests. **N**	1.26	.66	1.84	1.34	1.47	.98
2. Math is more boring when you use a calculator. **N**	1.47	.63	1.44	.58	1.46	.61
3. Calculators make math fun. **P**	3.00	.63	3.00	.71	3.00	.67
4. I will forget how to do math in my head if I use a calculator. **N**	1.98	.60	2.24	.93	2.07	.65
5. Math is easier if you use a calculator to solve problems. **P**	3.33	.61	3.32	.63	3.32	.61
6. Using a calculator is confusing. **N**	1.93	.55	2.08	.70	1.98	.61
7. I am more confident when I use a calculator to do math. **P**	3.30	.56	3.32	.69	3.31	.60
8. I make more mistakes when I use a calculator. **N**	1.84	.43	1.72	.54	1.79	.48
9. I try harder in math when I use a calculator. **P**	2.56	.70	2.72	.79	2.62	.73
10. Learning how to use a calculator is difficult. **N**	2.12	.63	2.16	.62	2.13	.62
11. My calculator was a waste of money. **N**	1.44	.50	1.68	.85	1.53	.66

Questionnaire Item	Females N=33		Males N=43		All N=76	
	$\bar{X}$	S	$\bar{X}$	S	$\bar{X}$	S
12. I understand math better when **N** I use a paper and pencil instead of a calculator.	2.28	.80	2.20	.65	2.25	.74
13. If given a choice, I would not **N** choose a math class that makes you use a calculator.	1.60	.58	1.92	.81	1.72	.69
14. My math grades are better when **P** I use a calculator.	2.84	.61	2.96	.79	2.88	.68
15. I do my math homework more **P** carefully when I use a calculator.	2.70	.60	2.68	.80	2.69	.67
16. I have never liked calculators. **N**	1.63	.54	1.76	.60	1.68	.56
17. I do better in math when I use **P** a calculator.	2.98	.64	3.04	.68	3.00	.65
18. I prefer working word problems **P** with a calculator.	2.67	.81	2.52	.85	2.62	.79
19. Working with calculators is **N** boring.	1.67	.57	1.88	.60	1.75	.58
20. I am a stronger math student **P** since I use my calculator.	2.67	.68	2.72	.79	2.69	.72
21. Everyone taking math should **P** have a calculator.	3.19	.73	2.96	.79	3.10	.76
22. My calculator was expensive **P** but worth the money.	3.42	.59	2.92	.86	3.24	.74
23. I rely too much on my **N** calculator.	2.19	.50	2.64	.64	2.35	.59
24. It is important that everyone **P** learn to use a calculator.	3.51	.51	3.28	.74	3.43	.61
25. I am going to take more math **P** classes than I had planned to since I can use my calculator.	2.16	.69	2.24	.78	2.19	.72

Research Question 2

The semantic differential instrument was designed to answer the second research question which was:

Is there a major difference in the perceptions and degree of enthusiasm for mathematics between ninth and twelfth grade students after instituting the use of graphing calculators?

The researcher calculated the mean response total and the standard deviation for the entire survey instrument. Responses ranged from 1 to 5 for each of the twenty adjective pairs. The researcher determined which of the bipolar adjectives in each set was considered the positive response. Responses that were closest to the positive adjective were scored as a 5 and responses that were closest to the negative adjective were scored as a 1. The scoring key that the researcher used for the semantic differential is given in Appendix B. The total score could have ranged from a low score of 20 to a high score of 100. A total score of 60 or more was considered to represent a positive perception of mathematics, and the higher the score, the higher the degree of enthusiasm for mathematics. A score of less than 60 was considered to represent a negative perception of mathematics, and the lower the score, the less the degree of enthusiasm for mathematics.

Responses were divided into groups in order to best answer the research question. The groups were: ninth grade females, ninth grade males, all ninth grade students, twelfth grade females, twelfth grade males, all twelfth grade students, total female students, total male students, and total students.

The t test for independent samples was conducted in order to compare the mean responses for the ninth grade students to twelfth grade students, and to compare the mean responses for the female students to the male students.

The survey results for the semantic differential instrument are presented here in Tables 3 and 4:

TABLE 3

MEAN RESPONSES TO SEMANTIC DIFFERENTIAL QUESTIONNAIRE

Response Group	N	$\bar{X}$	S
Ninth Grade Females	33	71.82	10.71
Ninth Grade Males	43	68.12	12.17
All Ninth Grade Students	76	69.72	11.48
Twelfth Grade Females	43	66.98	13.47
Twelfth Grade Males	25	61.28	13.86
All Twelfth Grade Students	68	64.89	13.51
Total Female Students - Both Grades	76	69.08	12.33
Total Male Students - Both Grades	68	65.60	12.71
Total Students - Both Grades	144	67.44	12.44

TABLE 4

TESTS OF SIGNIFICANCE

	Observed t Value*	Critical t Value**
Total Ninth Grade Students compared to Total Twelfth Grade Students	2.32	1.97
Total Female Students compared to Total Male Students	1.67	1.97

* Using the t Test for Independent Samples

** Using 2 degrees of freedom and $\alpha = .05$ (Gay,1987)

Discussion of the Results

Research Question 1

The Likert questionnaire was designed to analyze the perceptions of ninth and twelfth grade students toward the use of graphing calculators in mathematics. One would expect that if there were favorable perceptions toward calculators, then the subjects would strongly agree or somewhat agree with the questionnaire items that were positive statements about calculator use, and that the subjects would also disagree or strongly disagree with the negative statements about calculator use. Based on the scale from 1 to 4, a response of 2.5 or higher for a positive statement would be considered as agreement, and a response of less than 2.5 would be considered as disagreement. With only one exception, this is exactly what the researcher found. Statements like Item 3, "Calculators make math fun" invoked a very positive response, close to 3.00 or over in every response group. Similarly, the responses for Item 24, "It is important that everyone learn to use a calculator" were very positive, ranging from 3.02 to 3.51 depending on the response group. These high scores for the positive items were interpreted by the researcher as favorable perceptions toward graphing calculator use. The same could be said about every one of the positive statements toward calculator use, with the exception of Item 25, "I am going to take more math classes than I had planned to since I can use my calculator." Responses for this item ranged from 2.16 to 2.36, indicating that the subjects did not agree with the statement. The researcher considered that the reason for this is that this item might have been interpreted differently by some of the subjects than the researcher intended. The requirement for college admittance is currently at least three years of high school mathematics, and some high schools already require four years. All of the twelfth grade subjects in this study had already taken four years of high school mathematics, so perhaps those subjects interpreted the statement as referring to college level mathematics instead of the high school mathematics interpretation that the ninth grade students might have had.

Generally, the items that were negative statements about calculator use invoked disagreement from the subjects. A response of less than 2.5 on an item that was a negative statement was interpreted by the researcher as disagreement. For example, Item 4, "I will forget how to do math in my head if I use a calculator" invoked responses that ranged from 1.61 to 2.24, indicated that all of the response groups disagreed with that statement to some degree. Similarly, all of the items that were negative statements about calculator use had responses that were less than 2.5. These results were very consistent.

There were no items in which the ninth grade students agreed with a statement and the twelfth grade students disagreed with the same statement. The researcher concluded that there did not appear to be a major difference in the perceptions between ninth and twelfth grade students regarding the use of calculators in mathematics.

Similarly, there were no items in which the female students agreed with a statement and the male students disagreed with the same statement. The researcher concluded that there did not appear to be a major difference in the perceptions between male and female students regarding the use of calculators in mathematics.

The number of responses that agreed with the positive statements and disagreed with the negative statements were interpreted by the researcher as an endorsement of the use of graphing calculators in mathematics by the subjects in this study. The positive attitude toward calculator use that was observed in the classroom by the researcher appears to have been substantiated by the results of this study. Furthermore, the literature shows that these overall positive perceptions toward calculator use on the part of the students are to be expected (Dick & Dunham, 1994).

Research Question 2

The semantic differential questionnaire was designed to analyze student perceptions and degree of enthusiasm for mathematics after instituting the use of graphing calculators. As shown in Table 3, all of the subject groups had mean scores of 60 or above, which were interpreted as positive attitudes and perceptions overall toward mathematics by the researcher. Research shows that it is to be expected that the student attitudes toward mathematics after they are allowed to use graphing calculators would be positive (LaTorre, 1991; Paden & Templeton, 1991). Calculators have been shown to be a valuable tool for affecting students' attitudes toward mathematics by building their confidence and self-esteem (Dessart & Hembree, 1986; Finley, 1992; Nichols & Taylor, 1994). The results of this study appear to be consistent with those findings.

The ninth grade students had higher scores for both males and females than did the twelfth grade students. This could be interpreted as an indication that the ninth grade students had more favorable perceptions and a higher degree of enthusiasm toward mathematics than the twelfth grade students. The researcher conducted the t test for independent samples to determine whether there was a significant difference in the mean responses of the ninth grade students compared to the twelfth grade students, and to compare the mean responses of the female students compared to the male students. These test results are shown in Table 4.

In the case of ninth grade students compared to twelfth grade students, the observed t value exceeded the critical t value, so it the researcher concluded that it appeared that there was a significant difference in the perceptions and degree of enthusiasm for mathematics between ninth and twelfth grade students after instituting the use of graphing calculators that was attributable to something other than sampling error or chance.

One reason for the difference in the perceptions and degree of enthusiasm could have been that the ninth grade students had not had the opportunity to study high school mathematics without the use of graphing calculators, since the calculators were introduced this year at the beginning of their high school studies. In contrast, while the twelfth grade students had an overall positive attitude about mathematics, their responses were not as favorable as the ninth grade students'. This could have been because they had all had three years of high school mathematics without the use of graphing calculators or because they were more resistant to change than the ninth grade students, or for any number of other reasons that were beyond the scope of this study.

When comparing the responses of the female students compared to male students, the observed t value did not exceed the critical t value, so the researcher concluded that there did appear to be a major difference in the perceptions and degree of enthusiasm for mathematics between ninth and twelfth grade students after instituting the use of graphing calculators. However, since both groups had mean scores that indicated positive perceptions overall, the difference was in the degree of enthusiasm towards mathematics, with the ninth grade subjects seemingly more enthusiastic toward mathematics after instituting the use of graphing calculators.

In the case of female student responses compared to male student responses, the observed t value did not exceed the critical t value, so the researcher concluded that there did not appear to be a major difference in the perceptions and degree of enthusiasm for mathematics between male and female students after instituting the use of graphing calculators.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to analyze the changes in perceptions and attitudes of high school students toward mathematics after instituting the use of graphing calculators.

The research questions were:

1. Is there a major difference in perceptions between ninth and twelfth grade students regarding the use of graphing calculators in mathematics?

2. Is there a major difference in the perceptions and degree of enthusiasm for mathematics between ninth and twelfth grade students after instituting the use of graphing calculators?

A Likert questionnaire and a semantic differential survey were used to determine the student attitudes and perceptions toward mahtematics and the graphing calculator. The Likert instrument was used to answer and analyze the first research question and the semantic differential was used to analyze the second research question. The surveys were administered to 144 students in grade nine and twelve enrolled in the same high school, where graphing calculators had been introduced for use in all mathematics classes at the beginning of the 1994-95 school year.

The researcher calculated the mean response score and standard deviation for female ninth grade students, male ninth grade students, and total ninth grade students for each of the 25 items on the Likert questionnaire. The same thing was done for female twelfth grade students, male twelfth grade students, and total twelfth grade students.

There did not appear to be major differences in the mean response scores of the ninth and twelfth grade students, nor in the female and male students.

The researcher also calculated mean response scores for these same groups for the entire semantic differential instrument. A t test for independent samples was conducted, comparing the mean response scores of the ninth and twelfth grade students, and the mean response scores of the female and male students. There did appear to be a major difference in the mean response scores of the ninth grade students, where it appeared that their responses toward mathematics after instituting the use of graphing calculators was more favorable. There did not appear to be a major difference in the mean response scores of the male and female students.

Conclusions

The results of the Likert questionnaire led the researcher to conclude that the perceptions of the students toward the use of graphing calculators in the mathematics classroom were very favorable. The students agreed with the statements that expressed a positive attitude toward the use of calculators, and they disagreed with the statements that expressed a negative attitude. This was very consistent for both ninth and twelfth grade students, and for both female and male students. The study helped to quantify and validate the enthusiasm and vitality she had observed in her classroom since the introduction of these graphing calculators this past fall.

The semantic differential survey results assisted the researcher in concluding that there was an overall positive attitude toward mathematics on the part of most students after instituting the use of graphing calculators for this entire school year. There appeared to be a more positive attitude toward mathematics on the part of the ninth grade students, but there did not appear to be a major difference in the attitudes of female and male students -- both groups had positive perceptions toward mathematics after instituting the use of graphing calculators.

Recommendations

The researcher would like to expand the study to other schools and student populations, especially those schools where graphing claculators have yet to be introduced. The opportunity for a pre- and post-study would be of great interest to the researcher. These results could be used to help teachers and students to make the choice to use graphing calculators in a way that can change how students learn mathematics. Technology is clearly here to stay. This study provides additional research to show that using graphing calculators in the mathematics classroom can have real benefits in improving students' attitudes and perceptions toward mathematics that make it well worth the time and effort it takes to learn how to use them. Graphing calculators can empower students, giving them the tools and the confidence they need to become mathematical thinkers in our ever-increasing technological society.

APPENDICES

APPENDIX A

Data Collecting Instrument

Thank you for taking the time to complete these surveys. Their purpose is to help us to better understand the way students like you feel about graphing calculators and mathematics. Please answer the following questions carefully. There are no right or wrong answers, only your opinions and your attitudes. These surveys will be completed anonymously, and will not affect your grade in any way. Thanks again for helping us.

The Math Department

Please answer each of the following questions by filling in the blanks:

GRADE IN SCHOOL: (MARK 9, 10, 11, OR 12) ____________________

INDICATE YOUR GENDER BY MARKING:
F IF YOU ARE A FEMALE OR
M IF YOU ARE A MALE ____________________

MATH CLASS YOU ARE CURRENTLY TAKING: ____________________

PUT AN X NEXT TO WHICH EVER ONE OF THE FOLLOWING STATEMENTS APPLIES TO YOU:

I HAVE MY OWN GRAPHING CALCULATOR __________

I BORROW OR SHARE A GRAPHING CALCULATOR TO USE IN MATH CLASS AND AT HOME __________

I DO NOT HAVE A GRAPHING CALCULATOR TO USE EXCEPT WHEN I AM GIVEN ONE IN MATH CLASS. __________

Please turn the page and answer the following questions the best that you can.

Directions: **Circle** the answer that matches your attitude toward each statement. Please respond to every statement the best that you can.

CIRCLE **SA** IF YOU **STRONGLY AGREE** WITH THE STATEMENT

CIRCLE **A** IF YOU **AGREE** WITH THE STATEMENT

CIRCLE **D** IF YOU **DISAGREE** WITH THE STATEMENT

CIRCLE **SD** IF YOU **STRONGLY DISAGREE** WITH THE STATEMENT

1. You should not be allowed to use a calculator on math tests.	**SA**	**A**	**D**	**SD**
2. Math is more boring when you use a calculator.	**SA**	**A**	**D**	**SD**
3. Calculators make math fun.	**SA**	**A**	**D**	**SD**
4. I will forget how to do math in my head if I use a calculator.	**SA**	**A**	**D**	**SD**
5. Math is easier if you use a calculator to solve problems.	**SA**	**A**	**D**	**SD**
6. Using a calculator is confusing.	**SA**	**A**	**D**	**SD**
7. I am more confident when I use a calculator to do math.	**SA**	**A**	**D**	**SD**
8. I make more mistakes when I use a calculator.	**SA**	**A**	**D**	**SD**
9. I try harder in math when I use a calculator.	**SA**	**A**	**D**	**SD**
10. Learning how to use a calculator is difficult.	**SA**	**A**	**D**	**SD**
11. My calculator was a waste of money.	**SA**	**A**	**D**	**SD**

12. I understand math better when I use a paper and pencil instead of a calculator.	**SA**	**A**	**D**	**SD**
13. If given a choice, I would not choose a math class that makes you use a calculator.	**SA**	**A**	**D**	**SD**
14. My math grades are better when I use a calculator.	**SA**	**A**	**D**	**SD**
15. I do my math homework more carefully when I use a calculator.	**SA**	**A**	**D**	**SD**
16. I have never liked calculators.	**SA**	**A**	**D**	**SD**
17. I do better in math when I use a calculator.	**SA**	**A**	**D**	**SD**
18. I prefer working word problems with a calculator.	**SA**	**A**	**D**	**SD**
19. Working with calculators is boring.	**SA**	**A**	**D**	**SD**
20. I am a stronger math student since I use my calculator.	**SA**	**A**	**D**	**SD**
21. Everyone taking math should have a calculator.	**SA**	**A**	**D**	**SD**
22. My calculator was expensive but worth the money.	**SA**	**A**	**D**	**SD**
23. I rely too much on my calculator.	**SA**	**A**	**D**	**SD**
24. It is important that everyone learn to use a calculator.	**SA**	**A**	**D**	**SD**
25. I am going to take more math classes than I had planned to since I can use my calculator.	**SA**	**A**	**D**	**SD**

Directions: Read each set of words carefully. Then put an X in one of the five spaces on on that line. The closer you put an X to a specific word means that that word best describes your attitudes toward Math. Please put an X for every pair of words.

MATH IS

EASY	____	____	____	____	____	**DIFFICULT**
UNIVERSAL	____	____	____	____	____	**LIMITED**
DULL	____	____	____	____	____	**EXCITING**
BASIC	____	____	____	____	____	**UNNECESSARY**
SLOW	____	____	____	____	____	**FAST**
SIMPLE	____	____	____	____	____	**COMPLEX**
STUPID	____	____	____	____	____	**IMPORTANT**
VAGUE	____	____	____	____	____	**CLEAR**
PLEASURABLE	____	____	____	____	____	**PAINFUL**
EFFORTLESS	____	____	____	____	____	**TEDIOUS**
FAILURE	____	____	____	____	____	**SUCCESSFUL**
USELESS	____	____	____	____	____	**VALUABLE**
WEAK	____	____	____	____	____	**STRONG**
FASCINATING	____	____	____	____	____	**DISGUSTING**
TENSE	____	____	____	____	____	**RELAXED**
HELPFUL	____	____	____	____	____	**TROUBLESOME**
BORING	____	____	____	____	____	**INTERESTING**
THEORETICAL	____	____	____	____	____	**PRACTICAL**
MOTIVATING	____	____	____	____	____	**POINTLESS**
FUN	____	____	____	____	____	**WORK**

APPENDIX B

Key to Responses to Semantic Differential Instrument

MATH IS

EASY	5	4	3	2	1	DIFFICULT
UNIVERSAL	5	4	3	2	1	LIMITED
DULL	1	2	3	4	5	EXCITING
BASIC	5	4	3	2	1	UNNECESSARY
SLOW	1	2	3	4	5	FAST
SIMPLE	5	4	3	2	1	COMPLEX
STUPID	1	2	3	4	5	IMPORTANT
VAGUE	1	2	3	4	5	CLEAR
PLEASURABLE	5	4	3	2	1	PAINFUL
EFFORTLESS	5	4	3	2	1	TEDIOUS
FAILURE	1	2	3	4	5	SUCCESSFUL
USELESS	1	2	3	4	5	VALUABLE
WEAK	1	2	3	4	5	STRONG
FASCINATING	5	4	3	2	1	DISGUSTING
TENSE	1	2	3	4	5	RELAXED
HELPFUL	5	4	3	2	1	TROUBLESOME
BORING	1	2	3	4	5	INTERESTING
THEORETICAL	1	2	3	4	5	PRACTICAL
MOTIVATING	5	4	3	2	1	POINTLESS
FUN	5	4	3	2	1	WORK

Total for each survey could range from a low of 20 to a high of 100.

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