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The effect of graphing calculator use in Algebra One

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THE EFFECT OF GRAPHING CALCULATOR USE IN ALGEBRA ONE

by
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ABSTRACT

Anne Lawrence Hudock, The Effect of Graphing Calculator Use in Algebra One, 1996, J. Sooy, Mathematics Education.

The purpose of this study was to compare the learning of basic concepts of analytic geometry by students instructed with graphing calculators to that of students instructed by traditional methods. Three chapters, covering the basic concepts of analytic geometry, were taught to two separate algebra one classes at Salem High School, Salem, New Jersey over a nine-week period. The control group was taught using traditional instruction and the experimental group was taught using graphing calculator assisted instruction.

A unit test was administered to both the experimental and control groups at the conclusion of the study to evaluate student learning. From the results of an independent two-tailed t-test, it was found that there was no significant difference between the two groups.

MINI - ABSTRACT

Anne Lawrence Hudock, The Effect of Graphing Calculator Use in Algebra One, 1996, J. Sooy, Mathematics Education.

This study evaluated the effect of using graphing calculators in a high school algebra one unit on the basics of analytic geometry. Results showed that there was no significant difference between scores of the experimental group and the control group on a unit test.

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CHAPTER 1

Introduction to the Study

Introduction

This study discusses the use of graphing calculators in a high school algebra class. This chapter will include the statement of the problem, the significance of the problem, the limitations of the study, the definition of terms, and the procedures for implementing the study.

Background

The National Council of Teachers of Mathematics has long advocated the use of calculators at all levels of mathematics instruction, and graphing calculators are no exception. The availability of graphing calculators has motivated us to reexamine what and how we teach mathematics. (Dunham, 1994) The NCTM standards on algebra and functions for grades 9 - 12 were influenced by the capabilities of emerging graphing calculator and computer technology. This technology supports a vision of school algebra that focuses on conceptual understanding, symbol sense, and mathematical modeling. (Hirsch, 1995) Graphing calculators allow students to visualize the effect of a positive slope versus a negative slope, and a small slope versus a large slope. Students can come to conclusions about the slope of a line more quickly using the graphing calculator than by graphing several lines to see the different changes. This is just one of many examples of how the graphing calculator can be used to aid in the instruction of the basic concepts of analytic geometry. Several studies have been done at both the secondary and collegiate level as to the overall achievement between two groups, one group using graphing calculators and one not. The results have been mixed but encouraging. (Dunham, 1994)

Statement of the Problem

The purpose of this study is to compare the learning of basic concepts of analytic geometry by students instructed with graphing calculators to that of students instructed by traditional methods. The following hypothesis will be tested:

> H_0: There is no significant difference between the learning of basic concepts of analytic geometry by students instructed with graphing calculators and the learning of those instructed by traditional methods.

Significance of the Problem

Graphing is an effective problem solving strategy. It is useful in solving many problems in real life situations. The importance of understanding the basic concepts of analytic geometry is recognized by the New Jersey Department of Education, which includes items on slope, graphs of linear functions and linear patterns in three different clusters on the state High School Proficiency Test. The graphing caculator is a relatively new innovation which gives mathematics students a hands on approach with visual stimuli to aid them in understanding linear relationships. If this multimodal approach to teaching the basic concepts of analytic geometry is more effective than traditional methods, then use of the graphing calculators should be considered in mathematical instruction.

Limitations of the Study

Salem High School is a school with enrollment of 548 students. The percentage of seniors attending a 2 or 4 year college is 35%. The socioeconomic background of the high school is middle class. The sample population for this experimental study was taken from students enrolled in two sections of General Algebra One. The racial make-up of the school is 48% African American, 47% Caucasion, 5% Hispanic, .1 % Native American and .1 % Asian American. There were 25 students in the control group and 10 students in the experimental group. The racial make-up of the control group was 44% African American, 52% Caucasion and 4% Hispanic. The racial make-up of the experimental group was 60% African American, 40% Caucasion. Twenty-eight percent of the students in the control group were repeating the course. Forty percent of the students in the experimental group were repeating the course. Information sources for this research project are limited to those available through the Savitz Library of Rowan College and The National Council of Teachers of Mathematics.

Definition of Terms

Basic Concepts of Analytic Geometry: Point plotting, graphing linear equations, slope of a line, writing the equation of a line, parallel and perpendicular lines, solving simultaneous equations.

Control Group: The one of two groups that is not subjected to the experimental factor or condition, the effect of which is the purpose of the experiment to discover (Goode, 1972) For this study, it is the group using traditional methods of instruction.

Experimental Group: The one of two groups that is subjected to the experimental factor or condition, the effect of which is the purpose of the experiment to discover (Goode, 1972) For this study, it is the group using graphing calculators.

Graphing Calculator: For this study, the term graphing calculator refers to the TI-82 by Texas Instruments.

Learning: For this study, learning will refer to the percentages of correct responses on a unit test.

Traditional Methods: For this study, lecture with demonstration on the chalkboard and practice with paper and pencil.

Procedures for Implementing the Study

The study was conducted with students enrolled in two sections of General Algebra One at Salem High School, Salem, NJ, from February through March 1996. The subjects were randomly scheduled for the two algebra classes. The grade levels of the subjects ranged from 9 - 12, however the majority of the subjects were in grade 9.

In order to determine if the basic concepts of analytic geometry could be more effectively taught using graphing calculators, a course in Algebra was taught to two separate classes. The control group and the experimental group met for forty-two minutes, five times a week, both groups used the same textbook, covered the same topics, and received the same homework assignments, quizzes and tests.

The control group was taught using traditional methods of instruction with graph paper and pencil. For the experimental group, classtime was devoted to lecture as well as time for students to utilize the graphing calculators to visualize the material.

Learning was measured using the Publisher's unit test. An independent t-test was used to measure any significant differences in learning between the two groups.

The graphing calculator utilized for this study was the TI - 82 from Texas Instruments. The text used in the General Algebra One course was Holt Algebra 1, (1992). Activities used in the classroom to incorporate the graphing calculator were designed by the researcher.

CHAPTER 2

Review of Related Research and Literature

Introduction

The purpose of this study was to compare the learning of basic concepts of analytic geometry by students instructed with graphing calculators to that of students instructed by traditional methods. Related research studies which investigated the effect of graphing calculator usage on academic achievement have been done in high school algebra, pre-calculus and college elementary algebra courses.

The related literature discusses the need to change the way algebra is taught, using graphing calculators to enhance students' understanding of functions and graphing concepts

Review of Related Research

Graphing calculators are new enough that relatively little research concerning their use has found its way into educational journals. Doctoral disserations are the most fruitful sources of research on graphing calculators at this time.

In each study reviewed the researchers compared two or more groups to determine the effectiveness of graphing calculator use. In The Effects of the Graphing Calculator on the Achievement and Attitude of College Students enrolled in Elementary Algebra, Thomasson used a pretest-posttest control group design . The researcher used two instructors. Each taught three classes, one each of three modes of instruction. The three modes of instruction were: 1) total graphing calculator use by teacher and students, including tests, 2) partial calculator use by teacher and students, use of calculator was prohibited on test, 3) no calculator use by teacher or students. The null hypotheses tested were that there were no significant differences among the means of groups on: 1) algebraic achievement, 2) composite attitude, 3) mathematical attitude, and 4) calculator attitude. (Thomasson, 1992) The results indicated that students in the total calculator use group performed better on posttests of achievement, but this was not determined to be significant at the .05 level. There was no significant difference between the two groups in composite attitude or mathematical attitude. However, the mean of the calculator attitude scores for the total calculator use group was found to be significantly higher at the .05 level than the mean of non-calculator use groups.

A similar finding appeared in a study conducted by Scott (1994), indicating that although it was not statistically significant, students in an experimental group which used graphing calculators scored higher on posttests than students in a control group which did not use graphing calculators. Scott conducted his experiment using 170 Algebra 2 students and three teachers. Conic sections were taught to the experimental group using the graphing calculator; the control group was only allowed use of a scientific calculator during this six weeks of instruction. The purpose of Scott's study was to investigate not only the effect of graphing calculator use on achievement but also the effect it has on user attitude toward mathematics and confidence in learning mathematics. Highly significant differences ($p < .0001$) were found between the experimental and control groups in attitude and confidence in learning mathematics. Scott recommends further research to study the impact of graphing calculator use over an entire school year.

Another study, The Effect of the Graphing Calculator on High School Students' Mathematical Achievement, gathered information on the mathematics achievement of high school students who used a graphing calculator. Chandler used a directional research hypothesis, which stated that the mathematics achievement of high school pre-calculus students who used the graphing calculator to study transformations of functions is statistically significantly higher than the mathematics achievement of pre-calculus students who do not use it. (Chandler, 1992) The researcher used the pretest-posttest control group design. There were 4 pre-calculus classes in the control group and 5 pre-calculus classes in the experimental group. The study lasted for two weeks and the results appeared to be significant. The adjusted mean of the experimental group was statistically significantly higher ($p < .038$) than the adjusted mean of the control group. (Chandler, 1992) Chandler concluded that there is a positive increase in understanding and achievement when students are able to visualize the concepts on which they are working.

In Conceptual and Procedural Learning in First -Year Algebra Using Graphing Calculators and Computers, Ottinger investigated how learning concepts prior to procedures affected conceptual and procedural knowledge of algebra. The experiment consisted of a 39 subject experimental group and a 54- subject control group. The experimental group was instructed using graphing calculators, scientific calculators and computer software for computation, graphing and symbol manipulation. The control group used only scientific calculators throughout the experiment. The researcher developed an

Algebraic Procedure Test (APT) and an Algebraic Concepts Test (ACT). He also developed and used four questionaires and three interview guides. Scores on the APT pretest, APT posttest, and ACT pretest were not significantly different, but the experimental group scored significantly higher on the ACT posttest. Questionnaires and interviews showed that the experimental group had a better, more relational understanding of variables, functions, and equations and was better able to apply these concepts. Ottinger concluded that procedural knowledge is not necessarily a prerequisite for conceptual understanding, and procedures may be learned more rapidly if there is a strong conceptual base upon which to organize procedural knowledge. Using calculators and computers before pencil and paper instruction does not appear detrimental to learning pencil and paper algorithms and may promote a richer and more relational understanding of algebra concepts. (Ottinger, 1993)

The results of a study by Norris seem to confirm what Ottinger found. In The Impact of Using Graphing Calculators as an Aid for the Teaching and Learning of Pre-Calculus in a University Setting, Norris found no significant difference between his control group and treatment group in the area of algebraic skills. However, in the area of basic function concepts and graphing, the mean improvement in the performance of the treatment group was significantly better (p-value = 0.0003) than that of the control group (Norris, 1994).

The Effects of a Visualization-Enhanced Course in College Algebra Using Graphing Calculators and Video Tapes was a study conducted by Paschal which focused on the effects of a visualization-enhanced instructional environment on student achievement in College Algebra and student disposition toward mathematics and technology. The researcher used five groups for the study, three treatment groups and two non-treatment groups. Students in the three treatment groups used fully integrated graphing calculator technology. Two of the treatment groups viewed 15 content-oriented video tapes outside the classroom. Students in the two non-treatment groups studied College Algebra without technology. The results of the research revealed that students in the treatment groups scored significantly higher than the other students on the problem solving test and the connections test. Students in the treatment groups were more positive towards technology than the non-treatment students at the end of the experiment. Paschal concluded that graphing calculators helped relieve mathematics anxiety and equipped many students with a new confidence they did not have before using technology. This confidence enabled them to be better problem solvers.

Quesada and Maxwell reported similar findings in The Effects of Using Graphing Calculators to Enhance College Students' Perfomance in Pre-Calculus. This study extended through three academic semesters and involved 710 subjects. The study compared the performance of college students taught pre-calculus using a graphing calculator and a textbook written to be used with a graphing utility, to the performance of students using the traditional approach, a regular textbook and a scientific calculator. The results of the study indicated that the experimental group scored significantly higher on a comprehensive common final exam than the control group. The researcher believed that because the experimental group knew that they were part of an experiment that the Hawthorne Effect may have influenced the results of the study. (Quesada and Maxwell , 1994)

In an article entitled Research on Graphing Calculators, Dunham and Dick present an overview and discussion of some of the results of doctoral dissertations involving graphing calculator usage. The authors discuss results of studies that compare achievement of students who use graphing calculators with achievement of students who do not use graphing calculators. There seems to be a difference in the level of achievement between the two groups. However, it is generally not considered significant. The significant differences tend to appear when conceptual understanding is tested. Students using graphing calculators score significantly higher on tests of conceptual understanding. Dunhams review of research (1993) reports that many students who use graphing technology are better able to relate graphs to their equations, can better read and interpret graphical information, and better uderstand connections among graphical, numerical , and algebraic representations. These findings confirm the research of Ottinger (1993), Norris (1994) and Thomasson (1992).

Dunham's review of research (1993) also supports the claims that students who used graphing calculators were more successful on problem solving tests, had more flexible approaches to problem solving, were more willing to engage in problem solving and stayed with a problem longer and believed calculators improved their ability to solve problems. These findings support the works of Paschal (1994) and Scott (1994), which suggest that graphing calculators can affect attitudes of students.

The evidence supporting the use of graphing calculators with regard to students understanding of function and graphing concepts, problem solving and attitudes suggests that graphing calcuators can be a catalyst for mathematics learning.

Review of Related Literature

Powerful computer software, capable of changing the way mathematics is taught, has been developed in recent years. Graphic plotters, symbolic algebra systems, and numerical analysis packages have held great promise for use in the mathematics classroom. Dick (1992) reports that most schools however are not financially able to provide every mathematics student access to a personal computer for classroom activities and homework. In the mid 1980's scientific calculators with graphing capabilities began to appear on the market. Today, these calculators are more readily available and more affordable than computers. A set of 30 calculators, enough for one math class, costs about the same as one computer with comparable software packages. These calculators are capable of graphing functions and relations, manipulating symbolic expressions including symbolic differentiation and integration, computing with matrices and vectors, and performing high-precision numerical integration and root-finding of functions.

In 1989 the National Council of Teachers of Mathematics (NCTM) released a document entitled, Curriculum and Evaluation Standards for School Mathematics. An underlying assumption of the standards is that appropriate scientific calculators with graphing capabilities will be available to all students at all times (NCTM 1989). Frequent reference to graphing utilities (computers with appropriate graphing software or graphing calculators) is found throughout the standards. The NCTM recommends increased attention be placed on topics such as the use of graphing utilities to develop conceptual understanding and the use of graphing utilities for solving equations and inequalities. They suggest that topics such as paper-and-pencil graphing of equations by point plotting and the graphing of functions by hand, using tables of values receive less attention. The NCTM standards call for making explorations and problem solving a more central focus of instruction in school mathematics (NCTM 1989). Graphing calculators can be used to investigate, simulate and solve important real-world problems. According to Waits and Demana (1989) these calculators can be used to help students develop significant understanding about graphing. Graphs of functions and relations are easily accessible with the aid of technology. Producing graphs by hand takes so long that it is not possible to use graphing routinely to solve problems. With graphing calculators, students can obtain enough graphical evidence to make conjectures and then test them quickly with additional examples. (Demana and Waits 1990).

Graphing calculators give teachers the opportunity to change the way they approach mathematics instruction. Dick (1992) discusses the disadvantages of using traditional methods problem solving with graphing. Graphing of functions can be very time consuming and students tend to lose sight of the reason they are graphing the function. Instead of viewing graphing as a useful aid in mathematical analysis, students often come to view a graph as a task to be completed. Textbooks reinforce this idea by offering problems that are not really applicable to real world situations. The problems tend to be of an elementary form in order to yield successful outcomes for pencil and paper manipulations. Viewing the graph of a function can be the first step in problem solving instead of the last (Dick 1992). Day (1993) supports this idea, stating that the graphing calculator provides flexible, powerful and quick access to students, allowing them to become "accomplished analysis" instead of "mediocre manipulators" . Wilson and Frapfl (1994) also advocate the use of graphing calculators for classroom instruction. They report that students are now able to use graphs to solve problems that were traditionally solved using algebraic manipulations; problems that were considered unsolvable or too difficult to solve using algebraic methods. The TI - 82 allows students to relate the three common functional representations (table, graph, formula) and build conceptual links among these representations.

When students began using scientific calculators in mathematics classes, there were many critics, both educators and laypersons, who believed that calculator use would have a negative effect on learning. There are now those who criticize the use of graphing calculators in mathematics classes, suggesting that use of these instruments will diminish student understanding of graphing principles. However, Dion (1990) states that students using graphing calculators are required to have a higher level of understanding than that required for paper and pencil computation. Graphing calculators require student understanding and skill in the use of algebraic logic for the entry of expression, functions rules, equations and inequalities. Calculators also require students to judge the reasonableness of an answer and to estimate their answers. Burrill (1992) suggests that if students are to use graphing calculators effectively, they will need a solid understanding of the mathematical concepts involved, along with the ability to interpret the results. Dick(1992) also refutes claims of critics stating that students need scaling and positioning skills in order to be able to view the part of the graph that is appropriate to the problem that is being solved. The TI - 82 requires that students enter graphs in the form of "y=" , therefore students must be able to manipulate symbols, in order to enter the given equation. It is more likely that understanding of graphing principles would be improved rather than diminished by graphing calculator usage.

CHAPTER 3

Procedures

Introduction

This chapter explains the procedures used to determine the effect of graphing calculator usage on the learning of basic concepts of analytic geometry in a high school algebra one class. Included in this chapter is a description of the group of students studied, the instructional setting for the study, and the graphing calculator utilized. Learning was measured for both the control and experimental groups.

Population of the Study

The population of this study was taken from the student body of Salem High School in Salem, New Jersey. Salem High School includes grades 9 - 12, with a 1995 Fall enrollment of 548 students. The sample population consisted of students enrolled in two sections of General Algebra One, with twenty-five students in the control group and ten students in the experimental group.

Instructional Setting

This study was conducted over a nine-week period between January and

March, 1996. The control group and the experimental group met for forty-five minutes, five times a week.

The material covered during the study includes units on (1) relations and functions, (2) slope and equations of lines, and (3) systems of linear equations. The textbook used was Holt Algebra 1, written by Nichols, Edwards, Garland, Hoffman, Mamary, and Palmer.

For the control group, weekly class time was spent using traditional methods of instruction. This traditional method of instruction included reviewing the previous night's homework, presenting new material, assigning homework from the textbook, and testing. Aproximately thirty-five minutes of each forty-five minute class was dedicated to presenting, practicing, reinforcing and testing new material and previously acquired concepts.

Learning activities for the experimental group were similar to those used in the control group. A review of the previous night's homework, presenting new material, assigning homework from the textbook, and testing. Graphing calculators were used by the experimental group in each of the learning activities. The lessons were presented with the aid of an overhead graphing calculator. Students used graphing calculators during the presentation of the lesson, and in completion and review of homework. Student's were also allowed to use the graphing calculator during tests.

Description of the Graphing Calculator

The graphing calculator used for this experiment was the Texas Instruments TI-82. The TI-82 allows students to graph equations of linear functions in the form $y = mx + b$. The TRACE feature moves the cursor from one plotted point to the next along a function, while displaying the cursor coordinates at the bottom of the screen. Ths feature allows students to trace the graph and locate approximate intercepts and intersections of lines. The TABLE feature of the TI-82 provides numeric information about a function, listing a table of values for x and y. The ZOOM feature allows the user to adjust the viewing screen for a closer look at a specific area of the function. CALCULATE feature of the TI-82 enables the user to calculate the intersection of the fuctions being analyzed.

Achievement

In order to determine if the control group and the experimental group were equal in achievement before beginning the study, the student's semester averages were averaged together for each group. This average was used to find a t-value to determine if there were any significant differences. From the results of that independent two-tailed t-test, it was determined that the two groups had no significant difference in achievement from the start.

At the conclusion of the study, both groups were given the same comprehensive post-test consisting of 30 questions. The test, created by the publisher of the textbook was determined to be valid and reliable. An independent two-tailed t-test at the 0.05 level was utilized to determine if a significant difference in mean scores existed in achievement . The results were examined to determine the effect of graphing calculator use on the learning of basic concepts of coordinate geometry.

CHAPTER 4

Analysis of Data

Introduction

In order to determine the effect of graphing calculator usage in an algebra one class, data on learning was collected during the study. This chapter explains how the data was analyzed, what tables were made to show the results, what the results were, and what the results indicate.

Results

Before beginning the study, it was necessary to determine if the two groups were equivalent in mathematics ability. The student's first semester averages were used as their pre-test scores. The student's first semester average included the first and second marking period grade as well as a mid-term exam. Each marking period grade was counted twice and the exam grade counted once. The sum of these grades was then divided by five to determine the semester average. Individual semester averages are included in table form (Appendix B) for the control group and in table form (Appendix C) for the experimental group.

Table 1 shows the semester average mean for each group. The mean for the control group was 78.12 with a standard deviation of 8.560, and the mean for the experimental group was 78.4 with a standard deviation of 7.792. Using a two-tailed independent t-test, the value of t was found to be 0.0933 with 34 degrees of freedom. Since the t-value of 0.0933 lies between the critical values of +1.021 and -1.021 the null hypothesis is accepted at the 0.05 level of confidence. There was no significant difference in the learning of mathematics between the two groups prior to the study.

Table 1

Semester Averages

Group	N	Mean	S.D.
Control	25	78.12	8.560
Experimental	10	78.4	7.792

t = 0.0933

At the conclusion of the study, a unit test was administered to both the experimental and the control groups. Scores for the unit test are included in table form (Appendix B) for the control group and in table for (Appendix C) for the experimental group. Table 2 shows the percent of correct responses on the unit test for both groups. The mean score for the experimental group was 72.4 with a standard deviation of 25.5569 , while the mean score for the control group was 71.88 with a standard deviation of 21.5316. Using a two-tailed independent t-test, the value of t was found to be 0.0568 with 34 degrees of freedom. Since the t-value of 0.0568 lies between the critical values of +1.021and -1.021 at the 0.05 confidence level, the null hypothesis which states that there is no significant difference between the learning of basic concepts of analytic geometry by students instructed with graphing calculators and the learning of those instructed by traditional methods is accepted.

Table 2

Percent of Correct Responses on Unit Test

Group	N	Mean	S.D.
Control	25	71.88	21.5316
Experimental	10	72.4	25.5569

$t = 0.0568$

CHAPTER 5

Summary, Conclusions, Comments, and Recommendations

Introduction

This chapter will summarize what the results were and what they indicate. Also included in this chapter are the researcher's comments on the data findings and recommendations for further study.

Summary of Findings

In order to determine if graphings calculators can be used as an effective tool in the teaching of basic concepts of analytic geometry, three chapters in algebra one were taught to two separate classes. The control group was taught the material using the traditional instruction method, and the experimental group was taught the same material using graphing calculators. At the conclusion of the study, the learning of both groups was compared to determine the effectiveness of graphing calculator usage.

Learning was measured by administering a unit test to both the experimental and control groups. The mean score for the control group was 71.88% with a standard deviation of 21.5316, while the mean for the experimental group was 72.4% with a standard deviation of 25.5569. Using a two-tailed independent t-test, the researcher computed the value of t to be 0.0568 with 34 degrees of freedom. Since 0.0568 lies between the critical values of +1.0168 and -1.0168 at the 0.05 confidence level, the null hypothesis which states that there is no significant difference between the learning of basic concepts of analytic geometry by students instructed with graphing calculators and the learning of those instructed by traditional methods is accepted.

Conclusions

Based on the findings of this study, graphing calculator usage was not found to have a significant effect on the learning of the basic concepts of analytic geometry. The results of data analysis after the experimental treatment showed no significant difference in the unit test mean scores between the control group and the experimental group.

Comments

There was no significant difference between the learning of basic concepts of analytic geometry of the two groups. There are several factors that may have attributed to this result. The General Algebra One course at Salem High School is intended for those students who plan to attend a two-year college or trade school, these are not students who are considering math, science or engineering as a career option. Some students, in each group, could not sufficiently comprehend the algebraic concepts taught in the nine-week period. Students with poor or insufficient prerequisite skills experienced difficulty when the subject material became progressively more difficult.

Recommendations

Based on the findings and observations from this study, the following recommendations are presented for further study. The sample population should be larger and include students in college preparatory algebra as well as general algebra students.

This experiment took place over a nine week period. The units studied during this nine week period included only topics related to the basic concepts of analytic geometry. It is recommended that the study be conducted for a longer period of time and be expanded to include other topics that benefit the use of graphing calculators. Introducing the graphing calculator before the analytic geometry unit would allow the students to become familiar with the many other functions and capabilities that the graphing calculator offers. This would also enable the students to see the graphing calculator as a tool to solve many types of problems, not just a tool to assist in graphing.

Use of the graphing calculator involves a strong sense for the order of operations as well as the ability to solve equations for a given variable. Emphasis should be placed on these areas when planning to incorporate the graphing calculator into the algebra one classroom.

More research should be conducted to determine the best ways to integrate graphing calculators into the algebra curiculum. Use of graphing calculators should help promote the understanding of algebraic concepts and encourage thinking.

Appendix A
Chapters 10 - 12
Cumulative Test

Name________________Date________________Score________

Chapters 10 - 12
Cumulative Test

Given f(x) = 3x - 4, find each indicated value.

1. f(-1) 1.________
2. f(-6) 2.________
3. Use the domain D= {0, 2, 4} to find the range of f(x) = 6x - 1. 3.________
4. **Graph each equation in the coordinate plane.** 4.___(see graph)___
   a. x + y = 3 b. y = -4
   c. -2x + y = 1 d. x = -2

Find the slope of the line determined by the given points A and B.

5. A(1, 1), B(5, 4) 5.________
6. A(-2, -3), B(9, 3) 6.________
7. A(5, 2), B(4, 7) 7.________

Write an equation, in the form Ax + By = C, for the line passing through the given point and having the given slope.

8. P(-1, -5); slope = 0 8.________
9. P(8, 0); slope = -5/6 9.________
10. P(0, 0); slope = -5 10.________

Tell whether the lines are parallel, perpendicular, or neither parallel nor perpendicular.

11. $8x - 4y = 12$
    $8x + 4y = 8$

11.____________

12. $y = 7$
    $y + 2 = 0$

12.____________

13. $2y - 5x = 40$
    $5x - 2y = 1$

13.____________

Solve by the most convenient method.

14. $x + 2y = 3$
    $3x - y = -1$

14.____________

15. $y = 5 - 2x$
    $y = -x + 4$

15.____________

16. $-3x + 5y = 14$
    $3x + 8y = 12$

16.____________

17. $-7x - y = 19$
    $3x + y = -7$

17.____________

Solve each problem by using two equations and two variables.

18. The sum of two numbers is 15. Five times the first number minus 2 times the second is 12. Find the two numbers.

19. The sum of the digits of a two-digit number is 15. If the digits are reversed , the new number is 27 less than the original number. Find the original number.

20. There are 5 less dimes than nickels. The total value is \$4.00. How many coins are there of each type?

Appendix B
Midterm Averages and Unit Test Averages
Control Group

Control Group

Student	Mid-term Average	Unit Test Average
1	79	75
2	67	50
3	78	93
4	92	85
5	73	55
6	83	89
7	81	95
8	84	65
9	76	75
10	72	85
11	67	50
12	86	65
13	86	100
14	83	65
15	94	100
16	75	65
17	63	20
18	78	60
19	90	90
20	70	50
21	89	95
22	68	50
23	78	85
24	71	90
25	70	20

Appendix C
Midterm Averages and Unit Test Averages
Experimental Group

Experimental Group

Student	Mid-term Average	Unit Test Average
1	85	95
2	76	70
3	72	70
4	84	89
5	75	55
6	63	30
7	86	80
8	74	35
9	88	100
10	81	100

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