DOCUMENT RESUME

ED 434 030 SE 062 872

AUTHOR	Pennington, Robin
TITLE	A Study To Determine the Effect of Instruction in Effective Use of a Calculator on Test Scores of Middle School Students.
PUB DATE	1998-12-00
NOTE	54p.; M.A. Thesis, Salem-Teikyo University.
PUB TYPE	Dissertations/Theses - Masters Theses (042)
EDRS PRICE	MF01/PC03 Plus Postage.
DESCRIPTORS	*Calculators; Educational Technology; Elementary Secondary Education; Grade 8; *Mathematics Achievement; Mathematics Instruction; *Middle School Students; Middle Schools; Teaching Methods

ABSTRACT

The intent of this study is to determine whether or not teaching students how to use available calculators can improve their mathematics test scores. The study involved 89 seventh and eighth grade students. These students were randomly divided into three separate groups which included two experimental groups and the control group. The control group did not use calculators while one experimental group had access with no instruction on how to use them and the other experimental group had access with instruction. The design for this investigation was an experimental, three-group, pre-test/post-test design. The data were analyzed using a t-test of gain scores. The calculator used for this investigation was the Texas Instrument Math Explorer Plus. All three groups took a pre-test without the use of a calculator. Both experimental groups took the post-test two weeks later with the use of a calculator but one group had classroom instruction on how to use the calculators first. The results showed that at the end of the two-week period the test scores improved significantly when calculator instruction was given. Although test scores improved when students had access to calculators without instruction, there was no significant difference statistically. This indicates that students should be properly instructed on the use of calculators during classroom situations before using them in testing situations. (Contains 49 references.) (Author)

SE

A STUDY TO DETERMINE THE EFFECT OF INSTRUCTION IN EFFECTIVE USE OF A CALCULATOR ON TEST SCORES OF MIDDLE SCHOOL STUDENTS

A Thesis
Presented to
The Faculty of the Graduate School
Salem-Teikyo University

In partial fulfillment of the
requirements for the degree
Masters of Arts in Education

by

Robin Pennington
December 1998

ABSTRACT

The intent of this study is to determine whether or not teaching students how to use available calculators can improve their mathematics test scores. The study involved eighty-nine (89) seventh and eighth grade students. These students were randomly divided into three separate groups which included two experimental groups and the control group. The control group did not use calculators while one experimental group had access with no instruction on how to use them and the other experimental group had access with instruction.

The design for this investigation was an experimental, three-group, pre-test/post-test design. The data were analyzed using a t-test of gain scores. The calculator used for this investigation was the Texas Instrument Math Explorer Plus. All three groups took a pre-test without the use of a calculator. Both experimental groups took the post-test two weeks later with the use of a calculator but one group had classroom instruction on how to use the calculators first.

The results showed that at the end of the two-week period the test scores improved significantly when calculator instruction was given. Although test scores improved when students had access to calculators without instruction, there was no significant difference statistically. This indicates that students should be properly instructed on the use of calculators during classroom situations before using them in testing situations.

TABLE OF CONTENTS

CHAPTER 1 INTRODUCTION

Introduction	1
Statement of the Problem	3
Hypothesis	3
Purpose of the Study	3
Significance of the Study	4
Assumptions	4
Limitations	4
Definition of Terms	5

CHAPTER 2 LITERATURE REVIEW

Introduction	6
Historical Overview	8
Mathematics without Calculators	10
Technology Introduced	13
Mathematics with Calculators	19
Conclusion	28

CHAPTER 3 METHODOLOGY

Introduction	31

Research Question
Main Hypothesis 32
Sub-Hypotheses 32

Nature of Experiment
Sample Population 33
Method 33
Research Design 33

Summary 34

CHAPTER 4 RESULTS OF STUDY

Results 35

Main Research Question 36

Sub-Hypotheses 36

CHAPTER 5 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary 42

Conclusions 42

Recommendations 43

BIBLIOGRAPHY 45

CHAPTER ONE

INTRODUCTION

The National Council of Teachers of Mathematics has long advocated the use of calculators at all levels of mathematics instruction. In turn, the assessment of student achievement is reflecting these changes. Most people do not believe that simply carting a set of calculators into a classroom will have some magical effect on students (Dunham and Dick, 1994). Good instruction on how to use these machines and allowing students frequent access, will result in children developing self-confidence from experiencing success.

It is important to keep classroom calculators readily accessible to students. Just as counters, rulers, protractors, number lines, and many other items are stored on open shelves and available as needed, calculators must be kept in a visible location among the mathematics materials(Drosdeck, 1995). The Curriculum and Evaluation Standards of 1989 promotes the wide use of calculators in all mathematics classrooms:

> Appropriate calculators should be available to all students at all times... Calculators and computers for users of mathematics, like word processors for writers, are tools that simplify, but do not accomplish, the work at hand... Contrary to the fears of many, the availability of calculators and computers has expanded students' capability of performing calculations. There is no evidence to suggest that the availability of calculators makes students dependent on them for simple calculations. Students should be able to decide when they need to calculate and whether they require an exact or approximate answer. They should be able to select and use the most appropriate tool (NCTM 1989, p. 8).

It is important for students to use calculators in everyday situations. Using a calculator for the actual computation reduces the time needed to find a final answer. The calculator gives the students additional power beyond their paper-and-pencil abilities. Parents and students must be educated about students' activities so they will understand the place of a calculator in the total mathematics program. It should not be viewed as a tool for "cheating" but rather as a potential tool for learning (Drosdeck, 1995). The appropriate use of technology promotes active student involvement. Used appropriately in the classroom environment, technology becomes a valuable tool for learning (Day, 1996).

Student attitudes about mathematics seem to change when calculators are introduced. Frustration levels decrease, leaving the door open for learning. Increased motivation is important "because of the direct relationship between students' disposition to learn and their subsequent achievement" (Jenson and Williams, 1993, p. 226). Hirshhorn and Senk (1992) provide evidence of changed attitudes with the use of scientific calculators. One of the main advantages of using calculators during instruction is to help reduce the load on students' working memory so that more significant problems can be addressed. The use of calculators not only creates a computational advantage, but also helps students improve their selection of appropriate problem-solving strategies.

In a survey conducted to identify mathematics skills used in 100 different occupations, 98% of the respondents indicated they used calculators in their jobs (Sanders, 1988) However, results of the fourth National Assessment of Educational Progress(NAEP) indicated that, while most students had access to calculators at home, fewer than half used them in school settings. (Lindquist, 1989) Since calculators are frequently used in the "real" world, it

seems prudent for teachers to provide students opportunities to use them in school. Students gain self-confidence after many successes with using technology. It seems appropriate, then, for adequate training and access to calculators to be provided in classrooms.

Calculators are important tools for students and teachers to use to enhance learning, teaching, and assessment. Students need to learn flexibility in dealing with the power of calculators, since the calculator they use today is much less powerful than the calculator that will be available to them five years from now. Educators can go a long way toward helping students learn this flexibility by approaching the use of technology with an open mind and by exploring calculator capabilities along with the students. Learning is fun, and the changing technology gives students a chance to watch their teachers share in that joyous adventure. (Bright, Unsnich, and Lamphere, 1995)

RESEARCH QUESTION

What is the effect of proper instruction in the use of calculators on the mathematics test scores of middle school students?

HYPOTHESIS

There will be a significant difference between test scores in mathematics of students who receive calculator instruction and those who do not.

PURPOSE OF THE STUDY

The purpose of this study is to determine whether or not teaching students how to use available calculators can improve their test scores in mathematics. During this investigation, two groups used calculators, and the experimental group also first received instruction on how to correctly use Texas

Instruments Explorer Plus calculator. It was assumed that having calculators available would not impact student scores as much as showing proper use and having them available. The students in the experimental group who received proper instruction on correct use of available technology should have been the real winners of this study. Not only should they benefit from gaining confidence in the use of calculators, they should also show more interest in learning mathematics as they gain this confidence.

SIGNIFICANCE OF THE STUDY

The results of this study may be of interest to administrators, mathematics educators, and manufacturers of calculators, as well as parents and students. The National Council of Teachers of Mathematics (NCTM) states that calculators should be available for all students and the goals encourage the implementation of technology but leaves the "how" to the classroom teacher. This investigation may help classroom teachers realize that students must be taught how to use calculators; they cannot just be handed one with the expection that they will figure it out by test time.

ASSUMPTIONS

The students in all groups have similar abilities in math skills and were randomly selected. The students in all groups have similar socioeconomic status. The measuring instruments are valid and reliable. The sample is adequate in size. The sample is typical of seventh and eighth grade students. The time frame is adequate.

LIMITATIONS OF THE STUDY

The study is limited to eighty-nine seventh and eighth grade students. The study is limited to rural areas which are geographically and socio-economically similar. The measurement of the resultant outcomes were taken by means of MacMillan/McGraw-Hill Comprehensive Tests of Basic Skills.

DEFINITION OF TERMS

1. Calculators: portable or desktop devices, primarily electronic, that are used to perform arithmetic and other numerical processing operations at the direction of an operator or a stored program. (McGraw- Hill Encyclopedia of Science and Technology, 1987)

2. Scientific calculators: calculators with built-in functions capable of performing multiple operations and advanced mathematical operations eliminating the need of various tables.

3. Graphing calculators: Scientific calculators with graphing capabilities

4. Standards: A statement that can be used to judge the quality of a mathematics curiculum or method of evaluation. A statement about what is valued. (Curriculum and Evaluation Standards for School Mathematics, 1989)

5. NCTM: National Council of Teachers of Mathematics

6. Calculator-Neutral Items: Questions that can be answered appropriately with or without the calculator. (Mathematics Teacher, 1990)

7. Calculator Active: Questions that require the use of a calculator to answer the question adequately. (Mathematics Teacher, 1990)

8. Calculator Inactive: Questions where the use of a calculator would be ill-advised and inappropriate. (Mathematics Teacher, 1990)

CHAPTER TWO

LITERATURE REVIEW

INTRODUCTION

The research has shown that some beliefs are commonly held across various populations. These beliefs include the following:

- Mathematics is computation.
- Mathematics problems should be solved in less than five minutes or else something is wrong with either the problem or the student.
- The goal of doing a mathematics problem is to obtain the correct answer.
- In the teaching-learning process, the student is passive and the teacher is active(Spangler, 1992).

The past ten years have seen a remarkable amount of progress in improving mathematics education at all levels. The goal is to enable all students to master and appreciate mathematics. The emphasis is on understanding mathematics instead of thoughtlessly grinding out answers. Unfortunately in the past, much of mathematics was presented as a collection of rules for manipulating numbers and symbols. Much of the interest, beauty, and enjoyment vanished. A major thrust of the current reform movement is to get students actively involved in their study of mathematics and to encourage them to see the big picture. Mathematics is not merely a sequence of isolated topics that are to be struggled with, learned, and forgotten (Ross, 1996).

A cyclic relationship appears to exist between beliefs and learning. Students' learning experiences are likely to contribute to their beliefs about what it means to learn mathematics. In turn, their beliefs about mathematics

are likely to influence how they approach new mathematical experiences (Spangler, 1992). In recent years, there has been increased interest in students' beliefs about what it means to know and do mathematics. The predominant rationale for this interest has been the assumption that beliefs are an important influence on students' actions and achievement. (Kloosterman and Cougan, 1994).

This apparent relationship between beliefs and learning raises the issue of how the spirit of the curriculum standards may help enrich students' beliefs. The Standards document (NCTM, 1989) suggests that assessing students' beliefs about mathematics is an important component of the overall assessment of students' mathematical knowledge (Spangler, 1992). Kloosterman and Cougan (1994) found that students who enjoyed mathematics were also confident of their ability in mathematics. They also indicated that students with moderate achievement were just as confident of their abilities as high achievers, that most students believed it was important to learn mathematics, and that anyone who tried could learn mathematics. Specifically, students will not be highly motivated in school unless they believe that what they are learning will be of value to them and that effort will help them learn (1994).

Empowering students to make mathematical connections with the world in which they live requires that technology becomes an important player in the mathematics curriculum (Niess, 1993). The National Council of Teachers of Mathematics (1989) supports revising the mathematics curriculum toward "a coherent vision of what it means to be mathematically literate both in a world that relies on calculators and computers to carry out mathematical procedures and in a world where mathematics is rapidly growing and is extensively being applied in diverse fields" (NCTM, 1989, p. 8). However,

reports have identified widespread agreement that neither curricula nor instruction reflect the increased demand for higher-order-thinking skills, and that technology, including calculators, has had virtually no impact (Niess).

Technology is affecting the work force, changing not only the skills that are needed but also the level of those skills. Thus, the education of those workers who are assuming the newly defined positions must reflect the changes (Niess, 1993). Changes must also highlight mathematical connections to the real world using appropriate technology. Friel says, "We do not need to make changes simply for the sake of using technology, but we do need to make changes in order to reflect changes in the ways we think about and work within disciplines as a result of the enhanced intellectual provided through technology" (1990, p. 1). Niess adds, "Technology is changing what we need to know, how we need to know it, and how we need to learn it. For these reasons, changes must be made in the mathematics curriculum that reflect the critical-thinking skills of an information-based society" (Niess, 1993).

HISTORICAL OVERVIEW

Throughout history, most human beings have been unwilling or unable to do simple mathematics. The inability of most people to think mathematically has been an unfortunate negative factor in civilization's progress over the years. Recent advances in technology, however, and a world that is becoming continually more complex and quantitative, show that mathematical thinking is becoming ever more important. Furthermore, the kind of mathematics that people will need in an age of computers and calculators is different from the mathematics needed in the past (Willoughby, 1990).

Most technologically advanced societies have recognized the need for better mathematics education and are devoting enormous national, local, and individual resources to the task of improving the teaching of mathematics. Simple symbol manipulation can be done effectively by machines, but higher-order thinking skills and the ability to communicate intelligently about mathematical situations are still uniquely human skills (Willoughby, 1990). By reducing emphasis on manual skills, it will be easier to develop a curriculum that will allow all students some level of mathematical accomplishment while retaining the interest and enthusiasm of the more able students (Mathematics Sciences Educ. Board, 1990).

A broader curriculum stressing a variety of mathematical strategies will make it possible to teach material to students in each grade that will be useful to them no matter when they end their mathematics education (BMS, 1990). The school has as its primary task not only to serve children and to satisfy their immediate needs but also to equip them for service to society in their later life. Pupils must be taught a structure of arithmetic and sufficient applications of the structure so that in new situations, in life problems, they can use the structure for the necessary solutions of problems (Fehr, 1988).

Change in the teaching of mathematics is needed, not because it has recently deteriorated, nor even because it has always been bad, but rather, because the world is changing. That does not mean that the lower-order skills are no longer needed. Knowing the addition, subtraction, multiplication, and division facts is at least as important as it ever was, and many other lower-order skills are still essential so that students can concentrate on the higher-order skills. However, people of the future will need more, better, and different mathematical skills (Willoughby, 1990). Perhaps the most important

skills the schools can teach are flexibility and the ability and inclination to learn new things in the future (Willoughby).

Finally, computers and calculators have changed not only what mathematics is important, but also how mathematics should be taught (BMS, 1990). Students require an education in mathematics that goes beyond what was needed by students in the past (Dickey, 1997). Advances in technology are a reason for changing the mathematics curriculum and methods of teaching mathematics. These advances also provide tools that can be used to help change content and methods (Willoughby, 1990). Mathematics teachers in the United States are among the most innovative in the world. They make increasing use of technology and other teaching strategies that they themselves never experienced as students. Mathematics teachers will build on the moderate successes of the past decade and develop students' potential in mathematics into a wellspring for the nation's future (Dickey, 1997).

MATHEMATICS WITHOUT CALCULATORS

Until almost 1900, to be "great in figures" was to be learned (Suydam, 1982, p. 36). The mark of an educated person was the ability to compute. Most children stayed in school for only four, six, or eight years, learning little more mathematics than computation with addition, subtraction, multiplication, and division of whole numbers, and maybe a little about fractions. They needed no more for their futures of farming, carpentry, surveying, shopkeeping, or homemaking. Thus computation became synonymous with mathematics (Suydam, 1982).

Computation is a tool for solving problems in real-life situations. Thus, "computational skills are absolutely crucial" (Suydam, 1982, p. 41).

Attaining some level of proficiency in computation without the use of calculators is necessary. Knowledge of single-digit number facts is essential and mental arithmetic is a valuable skill. Moreover, there are everyday situations which demand recognition of, and simple computation with, common fractions. Throughout the twentieth century, even though the number of years of schooling increased and the number of career options expanded, the curriculum remained focused on computation. Computation was taught "chiefly for its usefulness in daily life, but also because of the training that it gives the mind"(Suydam, 1982, p. 37).

Arithmetic is a logical structure as well as a social instrument. Unless these two concepts are continually interrelated, educators will not succeed in reaching the objective of producing adults who know, recognize, and use arithmetic in their daily life problems. Pupils sense needs for arithmetic in the world about them, at home, on the radio, in the papers, in their games, and so on. They seldom sense a need for a complete understanding and mastery of a number system. Real problems, and problems to which reality can be given, may be used to show the pupils the need of knowing arithmetic. The experiences must create within pupils a drive that makes the learning of the arithmetic obligatory to them. Teachers can seize on all aspects of children's interest to motivate their learning. Instead of allowing outside interests to distract attention from arithmetic, a wise teacher uses them in promoting the study (Fehr, 1988).

Tradition plays a large part in shaping the curriculum. There are many arguments about why computational skills should continue to be taught. One factor related to this concern is that computational skill is viewed as a requirement for further mathematical study. "Essentially, computation is a hurdle which students must overcome or they will be excluded from a wide

range of options and occupations which require more advanced mathematics" (Suydam, 1982, p. 41). The arithmetic used for solving quantitative problems demands facility in computation that is obtained only through practice. However, the practice comes after meaning in varied situations and problems. Because of meaning, learning is faster, more permanent, and less practice is needed than is necessary for rote learning (Fehr, 1988).

To assist in thinking about teaching computation today and tomorrow, the following tenets are offered for consideration:

- Computational skill is one of the important, primary goals of a school mathematics program.
- All children need proficiency in recalling basic number facts, in using standard algorithms with reasonable speed and accuracy, and in estimating results and performing mental calculations, as well as an understanding of computational procedures.
- Computation should be recognized as just one element of a comprehensive mathematics program.
- The study of computation should promote broad, long-range goals of learning.
- Computation needs to be continually related to the concepts of the operations, and both concepts and skills should be developed in the context of real-world applications.
- Instruction in computational skills needs to be meaningful to the learner.
- Drill-and-practice plays an important role in the mastery of computational skills, but strong reliance on drill-and-practice alone is not an effective approach to learning.
- The nature of learning computational processes and skills requires purposeful, systematic, and sensitive instruction.

- Computational skills need to be analyzed carefully in terms of effective sequencing of the work and difficulties posed by different types of examples.
- Certain practices in teaching computation need thoughtful reexamination. (Suydam, 1982, pp.43-44)

Learning arithmetic stems from the needs for arithmetic as perceived by the learner. This need varies from student to student. Arithmetic can be learned only if it has meaning to the child. Meanings in arithmetic arise from thinking about things, from concrete experience, and from problem situations. However, meanings and experience are only the beginning. They must be organized into some sequential structure, and the facts must be made nearly automatic through practice. Thus meaning and understanding precede practice or drill. The final goal of all instruction is to develop within the mind of each child a problem-solving ability in quantitative situations. This ability is best acquired through a problem-solving approach to learning arithmetic operations as well as by practice in real problem situations (Fehr, 1988).

TECHNOLOGY INTRODUCED

Mathematics has taken an increasingly important role in everyday life. In this age of information and technology, society's expanding use of data makes it imperative that all citizens have an understanding of quantities. In order to ensure that every child is prepared for full participation in society, teachers, administrators, school board members, and other policy makers must be well informed regarding what children know and can do in school mathematics so that they can use this information to improve mathematics education (Kenny

and Silver; 1997). Of all the influences that shape mathematics education, technology stands out as the one with greatest potential for revolutionary impact (Dickey, 1997).

During the 1980's, educators saw numerous national reports calling for reform in mathematics. One common theme among these reports was the call for educators to more fully utilize technologies available to them, particularly calculators and computers, in the restructuring of mathematics curricula and instruction (Kenny and Silver, 1997). Within mathematics, Bitter (1987) asserted that in order to restructure the K-12 mathematics curriculum, educators would have to utilize newer technologies which would result in the introduction of practical problems that require the collection of data, communication of results, and the formulation and testing of results. The National Council of Teachers of Mathematics (1989) has vigorously supported the appropriate use of calculators, computers, and video technology as a means for students to explore mathematics content and to focus on problem solving.

The appropriate use of technology is an important component of mathematics learning, teaching, and assessment as educators strive to realize the vision of the NCTM's Standards documents and as they anticipate the arrival of the next millennium. Computers and calculators can make mathematics an active laboratory experience (Day, 1996). These technologies are furnishing increasingly more powerful learning environments for students. Both devices require and support enhanced development of students' mathematical reasoning. Calculators and computers can be used as tools for exploration and empowerment in school mathematics (Battista, 1994).

Teachers must start now to implement the many technologies currently available and prepare for the explosion of technology to come in this decade. School mathematics should be much more than the acquisition of arithmetic and algebraic skills. However, many students and their parents think mathematics consists only of dull arithmetic drill and endless algebraic manipulations. This belief reflects the way they were usually taught and tested. The importance of, and need for, highly proficient skill in arithmetic and algebraic paper-and-pencil manipulation in the workplace has already been rendered nearly obsolete by technology. It is important that educators help all students acquire the ability to make effective and appropriate use of technology (Demana and Waits, 1990). Appropriate use of technology can enhance opportunity for children to learn higher-order thinking skills without first mastering standard computational algorithms. Early informal experience with multiple approaches to arithmetic problems provides a secure base for subsequent study of standard techniques. Technology enables curricula to move beyond emphasis on mechanics to experience with ideas (BMS, 1990).

The appropriate use of technology to investigate problems "promotes active student involvement in doing mathematics" (Day, 1996, p. 136). Teachers play a vital role in shaping the learning environment, therefore, they ought to reflect on their behavior and on their expectations for the appropriate use of technology. "Technology has the potential dramatically to change the way we teach" (Demana and Waits, 1990, p. 28). Now that technology reduces the time needed for paper-and-pencil drill and practice, the expectations of school mathematics should be increasing students' ability to set up problems with appropriate operations rather than focusing on the computations and manipulations involved. It should be increasing students' ability to deal with open-ended, realistic problems rather than contrived,

simplified ones as well as increasing students' ability to understand the many connections between different representations of the same problem. It should also be increasing students' appreciation of the utility and value of mathematics. Technology can help students think more deeply about mathematics, facilitate generalizations, empower students to solve difficult problems, and furnish concrete links between geometry and algebra, algebra and statistics, and real problem situations and associated mathematical models (Demana and Waits, 1990).

Perhaps the most difficult challenge facing school mathematics programs is how to use new technologies. The resistance toward incorporating calculators and other technologies seems to result from the mistaken belief that they dull students' basic skills. On the contrary, the research suggests that students who first learn their basic facts and algorithms and then learn how and when to use a calculator grow significantly in their ability to solve problems, without losing ground in calculating ability, compared to students who do not use calculators (Dossey, 1988). Technology permits the student to focus on the analysis of the situation, knowing that the computation needed for subsequent trials will be facilitated through the technology, thus posing no real threat. This approach accomplishes one of the goals of the curriculum standards: to "free students from tedious computations and allow them to concentrate on problem solving" (NCTM, 1989, p. 67). Tomorrow's jobs will require workers who can do more than stroke calculator keys or write elementary programs in Basic. Students will have to know the new concepts and applications of mathematics that make the most use of computational technologies (Dossey, 1988).

The frequency of mathematics as a qualification for jobs is noted regularly in national reports on school reform. The need for such skills is embodied in

the new technologies that keep popping up in life. Preparing young people for jobs is one of the challenges facing mathematics education. In the future, adults will need to know more than what is thought of today as basic skills. They will need to know how to estimate and approximate, which in turn depends on skills in mental arithmetic and in testing for reasonableness and validity. The business world increasingly will need people who can collect, arrange, and interpret data (Dossey,1988). Technology offers students effective tools for exploring, conjecturing about, and verifying relationships among data sets. Students can use a calculator or computer to organize and manipulate the data, calculate numerical summaries, and display graphical representations (Day, 1996). America has an urgent priority in reforming mathematics and technology education. By the year 2000, an estimated 70% of jobs will be related somehow to the technology of computers, numeracy, and electronics (Rouse, 1988). Business leaders, public officials, and teachers argue that without solid skills in these areas students will not be prepared for even the most routine work (Aronowitz, 1990).

In teaching children to think scientifically and mathematically, it is important to help them to apply their understanding and skills in solving problems, discovering relationships, analyzing patterns, generalizing concepts, and using numbers with confidence. Incorporating application with collaborative strategies can assist students in taking responsibility for their thoughts as they use higher level thinking skills and build inner confidence (Hamm, 1992). Making intelligent use of technological innovations requires more thinking, problem formulating, and interpersonal communication skills (Foreman and Pufall, 1988).

Students using technology become good problem solvers and develop a deeper understanding of algebraic concepts and procedures. Even

performance on standard test items requiring algebraic manipulation has improved substantially. The future will involve further and more rapid advances in technology. Schools must help students meet the challenges of lifelong learning that surely lie ahead. Students must be trained as flexible problem solvers, capable of understanding and employing technological advances as these advances occur. This generation of students will soon hold the power of today's main-frame computers in their hands (Demana and Waits, 1990).

Technology makes possible earlier introduction of certain topics and students who become comfortable using technology can and will ask good, hard questions. Technology is here to stay. The modern workplace is increasingly dependent on technology. The ability to use technology effectively and the ability to reason mathematically are crucial skills for the future success of students. Teachers must learn to use it effectively because its increasing presence in society leaves no choice (Demana and Waits, 1990). Teachers who use technology in education today are helping students develop the thinking patterns that pave the way toward successful futures (BMS, 1990).

Increased use of technology in mathematics education is inevitable, but wise use is not automatic. Technology has more to offer education than just high-tech flash cards. Effective use of technology requires objectives for mathematics education that are aligned with the mathematical needs of the information age (BMS, 1990). Some traditional paper-and-pencil skills will continue to be necessary for mathematical activities, as will traditional mental-mathematics skills. However, everyone must also agree to stop spending large portions of time teaching obsolete paper-and-pencil manipulation. These obsolete skills must be identified and de-emphasized in

the curriculum. Doing so is the challenge for the future. What is needed now is a mathematics curriculum that takes advantage of technology to assist students in becoming powerful and thoughtful problem solvers (Demana and Waits, 1996).

MATHEMATICS WITH CALCULATORS

Rapid developments in technology are changing the way educators teach mathematics both because they modify goals for the mathematics education of people and because they provide new tools with which the goals can be achieved. Calculators are here to stay and will continue to become more useful and easier to use. Conversely, it seems to be true that people will always be able to do certain things that machines cannot do and should be educated to do those things well rather than being trained to do what a cheap calculator can do better (Willoughby, 1990).

The most obvious reason for teaching children to use calculators is that they are all around in the world outside of school, and most people who have access to them do not use them very intelligently. Since calculators can be very powerful tools in doing mathematics, one of the obligations of a good mathematics education program in a school is to teach students how to use calculators intelligently. Beyond that, it is hard to convince children that school mathematics has something to do with the real world if everybody outside of school is doing mathematics with calculators but students are not allowed to use them in school (Willoughby, 1990).

In a survey conducted to identify mathematics skills used in one hundred different occupations, 98% of the respondents indicated calculators were used in their jobs. However, while most students had access to calculators at

home, fewer than half used them in school settings (Usnick, Lamphere, Bright, 1995). Since calculators are used frequently in the real world, it seems prudent for teachers to provide students opportunities to use them in school. The National Council of Teachers of Mathematics (NCTM, 1989) has long advocated the use of calculators at all levels of mathematics instruction. In turn, the assessment of student achievement is reflecting these changes (Dunham and Dick, 1994). For example, on the 1995 Advanced Placement calculus examination, the College Board will require the use of a graphing calculator. Using calculators on standardized tests has the potential to force the implementation of the evaluation standards. Many critics of standardized tests in mathematics call for a reduced emphasis on arithmetic calculations on tests, a goal that can be accomplished by the use of calculators. Routine arithmetic will no longer be tested, since computation items measure only the candidate's ability to perform calculator operations and not mathematical ability. Therefore, test writers will have to develop nonstandard settings within which to test simple ideas, and students will be required to apply the material in unfamiliar contexts (Kenelly, 1990).

Significant moves are under way in the testing industry to incorporate the use of calculators in standardized testing of mathematics. When calculators are used during an examination, testing experts must be certain that the machine's ability to perform mathematics does not interfere with the test's ability to measure the candidates performance in mathematics (Kennely, 1990). Students should be able not only to use a calculator but also decide when to use one. These abilities can be tested when calculator-active items are mixed in with calculator-neutral and calculator-inactive items. "Calculator active questions require the use of a calculator to answer the question adequately. For calculator inactive questions the use of a calculator

would be ill-advised and inappropriate. Calculator neutral questions can be answered appropriately with or without the calculator" (Kenelly, 1990, p. 717). Calculators have a place in standardized testing, which is an important part of educational accountability. The test items must change when the use of these mathematically powerful and useful instruments is allowed on standardized tests, and the changes will reinforce the goals of NCTM's Standards (1989).

In order to effectively use calculators in assessment situations, students should have prior experiences with the technology during the learning phase. One of the main advantages of using calculators during instruction is to help reduce the load on students' working memory so that more significant problems can be addressed. The use of calculators not only creates a computational advantage, but also helps students improve their selections of appropriate problem-solving strategies. "Classroom teachers at all grade levels must now face the prospect of having to change both how they teach mathematics as well as what mathematics they teach" (Usnick, Lamphere, and Bright, 1995, p. 11). Most teachers did not learn mathematics with the help of technology, so time is needed to adjust to both a new learning environment and a new teaching one.

It is certain that technology will increasingly be used to teach mathematics. Some states have mandated that use of technology be integrated into instruction provided by textbooks. Proper use of technology would exploit its unique capabilities to improve the learning of mathematics or to teach both old and new mathematics in new ways. The use of technology does not mean merely the delivery of the same instruction through alternate media (Bright and Prokosch, 1995). The availability of powerful calculators plays a fundamental role in the current calls for reform in the

mathematics curriculum. Rather than being just tools to be used in the mathematics classroom, this technology is helping redefine what school mathematics should be (Dick, 1992). As the Mathematical Sciences Education Board's influential document Everybody Counts (1989) states:

> The ready availability of versatile calculators and computers establishes new ground rules for mathematics education. Template exercises and mimicry mathematics--the staple diet of today's test--will diminish under the assault of machines that specialize in mimicry. Instructors will be forced to change their approach and their assignments. It will no longer do for teachers to teach as they were taught in the paper-and-pencil era. (p. 63)

The NCTM (1989) wrote, "Some calculations, if not too complex, should be solved by following standard paper-and-pencil algorithms...For more complex calculations, the calculator should be used" (p. 89). The calculator is ubiquitous in many societies, and there is no evidence that children make more errors when using a calculator than they ever did with pencil and paper. The algorithm can be best understood through simple short divisions; the algorithm can best be carried out by means of the calculator. Furthermore, the pencil-and-paper algorithm is very much a product of Western mathematics. The abacus has long provided the means of carrying out arithmetical processes in the Eastern world. There is evidence that most adults, even those educated through older, more traditional curricula, are not able to handle simple algorithms such as those concerning fractions, so this deficiency cannot be simply attributed to modern teaching (Wain, 1994).

The major concerns of teachers who hesitate to use calculators in classrooms usually focus on a fear that computational skill development will be retarded by the calculator. A review of the current literature showed that

skills were not lost when children were allowed to have access to calculators. No measurable negative effects were associated with the use of calculators for teaching mathematics. The researchers observed that teachers who had not used calculators in the classroom believed there would be detrimental factors, whereas teachers who had used calculators in the classroom found them to be a worthwhile tool (Wyatt, et al, 1994). Several studies have found that calculators help develop mastery of the four operations of arithmetic (Suydam, 1979). The implications are that if the entire school community became familiar with the calculator and its potential for instruction, interest in and motivation toward mathematics would increase (Hill, 1982).

One of the most powerful and consistently reported effects of student use of calculators is the high enthusiasm and valuing students have for calculator-aided mathematics activities. Any device which causes so much pleasure to be associated with mathematics and increases the probability appropriate mathematics strategies will be chosen for problem solving deserves special note (Weaver, 1981). Parental openness to calculator use can be influenced significantly by the enthusiastic response children exhibit for calculated-aided mathematics. So in the pragmatic real-world problems of making calculators available to all children, such attitude results are most important. Increased motivation is important for middle grades students "because of the direct relationship between students' disposition to learn and their subsequent achievement" (Jenson and Williams, 1993, p. 226). One worthy aim for teachers of mathematics is to attempt to keep learners constantly attentive and motivated, to enable students to come to believe that the subject is relevant and worth studying. Learners of all ages can quickly become demotivated if they perceive the curriculum to be dull and boring, if their interpretation of what is expected of them is that it is without real

purpose, has no relevance to reality as they see it, or is too hard and unintelligible. In other words, children will deduce their own views of the purposes of learning mathematics and of the aims which underlie particular aspects of the curriculum, and one might be horrified by their deductions (Wain and Orton, 1994).

Today there are no jobs that require a clerk to do lengthy arithmetic calculations using pencil and paper, but it is still important to understand arithmetic. A handheld calculator can save hours when doing an income tax statement, but it is useless if one does not understand, for example, percent (Hawthorne, 1979). Students frequently describe helping their parents learn to use a calculator to balance monthly statements. It is important for students to use calculators in everyday situations (Drosdeck, 1995). The calculator gives the students additional power beyond their paper-and-pencil abilities. Calculator availability to students outside school mandates that teachers implement practices which reflect their own or their school's policies in dealing with this fact. As teachers require mathematics homework today, they must consider the fact that the vast majority of their students will have a calculator to use in completing the assignment (Hill, 1982). Instructional techniques need to be upgraded so that students do not tune out just because they have seen all that before (Bright and Prokosch, 1995).

Middle school is an ideal time for students to become comfortable with the use of technologies of all sorts. Making middle school instruction more exciting and more accessible might help encourage future course taking (Bright and Prokosch, 1995). It would be well to note that calculators are the quickest, most accurate computational algorithms available to children today. In fact, the primary function of a calculator is to compute, and in the hands of children, the calculator serves the computational function better than any

other technique or device in existence (Weaver, 1981). As Hamrick and McKillip point out, the goal should not be to turn "the student into a calculator, albeit a slow and inaccurate one" (1978, p. 2). What is needed is a student who can compute without a calculator when it is more convenient to do so and, most important of all, a student who can apply computational skills in the ultimate test of solving problems. In short, students should have the computational skills they really need for tomorrow, along with other mathematical skills of vital importance (Hamrick and McKillip, 1978).

A growing volume of research supports appropriate use of calculators in any grade. It is now clear that an understanding of arithmetic can be developed with a curriculum that uses estimation, mental arithmetic, and calculators, with reduced instruction in manual calculation (BMS, 1990). Currently, there are calculators costing less that one hundred dollars that can perform most of the mathematical symbol manipulation taught in schools between kindergarten and the second year of calculus. The machines can do arithmetic with whole numbers, rational numbers, complex numbers, and vectors. They can solve equations and systems of equations; they perform graphing functions and can zoom in on parts of the graph to get a magnified picture. Machines can perform algebraic differentiation, integration of functions, and most other mathematical symbol manipulations taught in schools and colleges (Willoughby, 1990). Today, calculators are an everyday feature of mathematics lessons and logarithm tables are a feature of the past (Wain and Orton, 1994).

In a study examining student performance on algebraic tasks, Ruthven (1990) found that an experimental group of students using calculator technology outperformed a traditional group on items requiring students to examine certain graphs and describe them algebraically. Students in the

calculator group were more successful in identifying the family of curves to which a graph belonged and in refining the algebraic representation to better fit the graph. When algebra students, who received technology-integrated instruction, were compared with students who had traditional instruction, Boers-van Oosterum (1990) reported data from interviews and testing indicated that the experimental group used more varied, flexible approaches for solving problems and was better able to relate graphs to their equations. Thomasson (1993) reported that students who were allowed to use graphing calculators both in class and during examinations performed better in terms of achievement than did students who had either limited or no access to graphing calculators. Students who had full access to graphing calculators had a significantly better attitude toward calculator use than did other student groups (Smith and Shotsberger, 1997).

Calculators must be seen as extensions to a person's ability to do mathematics. There is always the possibility that a calculator will be used to perform trivial calculations which could have been done mentally. The evidence, however, seems to suggest that regular users soon achieve a balance between the use of the machines and other methods. Where the balance is struck will depend on the individual. For those who find the simplest mathematical work difficult, the calculator may be the key to providing access, for the first time, to achievement and success in the subject. For the ablest young people, the calculator has the potential to allow them to develop their mathematical skills to levels far beyond those traditionally expected (Wain and Orton, 1994). The calculator makes the problems clearer and makes them less time consuming. It takes out a lot of the unnecessary work. If people are going to be able to use calculators in their future jobs, why not use and learn them now? The calculator is a tremendous help and

should be used in future courses (Smith and Shotsberger, 1997). The reality is that calculator use is now a normal activity and it would seem apparent that one task of education is to ensure that people are able to make effective use of them at whatever level is appropriate for the individual (Wain and Orton, 1994).

Students often indicated a heightened confidence in their ability to do the required mathematics when using calculators. The calculator gives one a better understanding of the material covered in the course. More than 70% of the students specifically identified the calculator as helping them to understand more fully or to see certain ideas better (Smith and Shotsberger, 1997). Students' attitudes about mathematics changed when calculators were introduced (Bright and Prokosch, 1995). "A calculator is a learning aid and one that students enjoy using" (Seitz and Parks, 1982, p. 85). The calculator frees the teacher from awaiting tedious computation when introducing such concepts as partial products or the inverse processes of multiplication and division. The ease of handling large numbers with a calculator opens doors for exploring concepts that otherwise must wait for complete learner mastery and proficiency in computation (Seitz and Parks, 1982). Since calculators increase the speed and accuracy with which children can do calculations, much more time will be available to learn the concepts and principles of mathematics (Burt, 1979). The most important suggestion for using calculators in the classroom is to view the calculator not as a danger or as a mere computational device but rather as a tool that can support students' constant involvement in mathematical reasoning and exploration (Battista, 1994).

CONCLUSION

Advances in technology are a reason for changing the mathematics curriculum and methods of teaching mathematics. These advances also provide tools that can be used to help change content and methods. Some changes ought to be made in the school curriculum to prepare children to use calculators more intelligently. However, rather than simply continuing to teach students all the skills and knowledge that have been assumed to be useful in the past, teachers must now decide which abilities people of the next century will need and which they will not need. There is a limited amount of time for educating people, and none can be wasted teaching things that are certainly going to be useless. On the other hand, educators must not forget to teach them the more mundane skills that are prerequisite to the higher-order skills (Willoughby, 1990).

The character of mathematics is changing, with developments in new technology progressing at a rapid pace. Mathematics teachers at all levels need to respond to the changes. Research studies generally support the view that new technology can improve learning (Wain and Orton, 1994). Experiencing various opportunities to use calculators as an integral part of the curriculum throughout the year helps students to value the use of a calculator and to judge when that use is appropriate (Drosdeck, 1995). Calculators should be used in imaginative ways for exploring, discovering, and developing mathematical concepts and not merely for checking computational values or for drill and practice (Weaver, 1981). Skills are tools. Their importance rests in the needs of the times. Skills once considered essential become obsolete, and this is likely to increase in pace and scope as advances in technology revolutionize individual, social, and economic lives (Suydam,

1982). The calculator provides unique opportunities for young learners to develop ideas and investigate relationships. It is no longer a question of whether the calculator should be used, but how and when it can best be used and integrated into the curriculum at all grade levels (Schielack and Dockweiler, 1992).

Mathematics instruction should prepare students to cope with the real world, and since computers, calculators, and other mechanical devices are used regularly in commerce, business, and industry, their incorporation into the basic structure of mathematics curriculum seems necessary and appropriate (Palmer, 1979). A nice analogy could be drawn between computational skills in mathematics and carpentry. "Skill in making cuts with either a handsaw or an electric saw does not a carpenter make" (Dick, 1992, p. 2). Knowing when and where and how to make the proper cuts is the key knowledge, as long as some appropriate tool is used. Similarly, skill in using either a written algorithm or a slide-rule or a calculator in and of itself cannot be a proper objective for mathematics education but knowing when and where and how to apply appropriate mathematical tools should be. A powerful calculator can only help us carry out a plan. "People, not black boxes, do mathematics" (p. 4). They provide students and teachers both more time and power for thinking mathematically (Dick, 1992).

There is now substantial research available that shows that use of calculators does not interfere with the learning of necessary skills. Numerous studies have been conducted at all levels and have shown that the use of calculators does not interfere with the learning of basic number facts, with other forms of computation, or with the learning of any other skill that is commonly thought to be useful (Willoughby, 1990). With respect to classroom management, student motivation, and academic achievement,

teachers seem to view the use of calculators positively. Several studies cited by the teachers indicated that significant gains in student achievement resulted from calculator use. Many stated that the use of calculators increased enthusiasm for mathematics on the part of both teachers and students, improved class attendance, motivated students to learn, provided concrete reinforcement of skills and concepts, and freed students from the tediousness of computation (Palmer, 1979).

The use of calculators will never replace the need for understanding mathematical concepts, basic skills, or the teaching of mathematics. They will, however, increase the teacher's opportunities for providing insights into mathematics while increasing each school's academic responsibilities for providing an additional depth and breadth of topics within the existing curriculum. An effort should be made to maximize the relationships between physical paper-and-pencil or calculator and mental mathematics through effective classroom presentations (Caravella, 1977). The movement to integrate technology into the mathematics curriculum is related to the shifts in mathematics itself. If school systems support coming changes in mathematics education by adopting improved textbooks, instructional materials, and evaluations that monitor student achievement, there will be a strengthening of mathematics instruction. If school systems continue to integrate technology into their mathematics programs and if they commit themselves to developing mathematics teachers through in-service education, mathematics instruction will strengthen even more (Dossey, 1988). "Used appropriately, technology becomes a valuable tool for learning" (Day 1996, p. 137).

CHAPTER 3

METHODOLOGY

INTRODUCTION

Students need to be properly instructed on how to use calculators that will be available to use during testing situations. The purpose of this study is to determine whether or not teaching students how to use available calculators can improve test scores. During this investigation, two experimental groups used calculators, but experimental group B first received instruction on how to use Texas Instruments Explorer Plus calculator correctly, whereas experimental group A received no instruction but was allowed to use these calculators during the post-test. The students in experimental group B who received proper instruction should not only have benefitted from gaining confidence in the use of calculators, but should also have showed more interest in learning mathematics as they gained this confidence.

The results of the study may be of interest to administrators, mathematics educators, and manufacturers of calculators, as well as parents and students. The National Council of Teachers of Mathematics (1989) states that calculators will be available for all students and the goals encourage the implementation of technology but leaves the "how" to the classroom teacher. This investigation may help classroom teachers realize that students must be taught how to use calculators, not just handed one and expected to figure it out by test time.

Students should learn how to use technology as a tool to help them solve their problems. They should learn when it is appropriate to use technology,

and they should always expect to do the real thinking about when and how to use the technology and what the answers produced by machines mean. The calculators used for this investigation were the Texas Instruments Math Explorer Plus. In addition to performing as a four-function calculator with algebraic operating system, this machine has the capability of displaying remainders in division problems as integers or as decimals. Of potentially greater use to middle school teachers is its capability to operate on common fractions and display the results in fairly traditional format.

RESEARCH QUESTION

What is the effect of proper instruction in how to use calculators on the mathematics test scores of middle school students?

MAIN HYPOTHESIS

There will be a significant difference between test scores in mathematics of students who receive calculator instruction and those who do not.

SUB-HYPOTHESES

There will be a significant difference between mathemetics test scores of students who have access to calculators and those who do not.

There will be a significant difference between pre- and post-test scores in mathematics for experimental group A.

There will be a significant difference between pre- and post-test scores in mathematics for experimental group B.

NATURE OF EXPERIMENT

SAMPLE POPULATION

The students in all three groups, control and both experimental, have similar socioeconomic status. All students were from the Montcalm area in southern West Virginia. The students have similar abilities in math skills and were enrolled in either Math 7 or Math 8 and were randomly selected for the groups.

METHOD

All three groups took a pre- and post-test from the MacMillan/ McGraw-Hill Comprehensive Tests of Basic Skills. The control group took both pre- and post-test without using a calculator. No special instruction was given to the control group. Experimental group A took the pre-test without a calculator and two weeks later were handed a calculator with no instruction on how to use it and given the post-test. Experimental group B also took the pre-test without the use of a calculator. Then for the next two weeks, three days a week for forty minute sessions, these students received instruction on how to use the Texas Instrument Explorer Plus. This was a total of six sessions. These students were then allowed to use these calculators during the post-test.

RESEARCH DESIGN

The design for this investigation is an experimental, three-group, pre-test/post-test design. The data were analyzed using a t-test of gain scores to test the following hypotheses:

1. There will be a significant difference between mathematics test scores of students who receive calculator instruction and those who do not.
2. There will be a significant difference between mathematics test scores of students who have access to calculators and those who do not.
3. There will be a significant difference between pre- and post-test scores in mathematics for experimental group A.
4. There will be a significant difference between pre- and post-test scores in mathematics for experimental group B.

SUMMARY

The use of calculators has long been advocated at all levels of mathematics instruction. With good instruction on how to use these machines and allowing students frequent access, children develop self-confidence from experiencing success. Used appropriately in the classroom environment, technology becomes a valuable tool for learning. As the research indicated, calculators were used for student assessment and students need to be properly instructed on how to use calculators that were available during testing situations so their test scores would improve. The results of this study are presented in Chapter Four.

CHAPTER FOUR

RESULTS OF STUDY

The purpose of this study is to determine whether or not teaching students how to use available calculators can improve test scores. During this investigation, two experimental groups used calculators on the post-test, but experimental group B first received instruction on how to use Texas Instruments Explorer Plus calculator correctly. The population of this study included eighty-nine (89) seventh and eighth graders between the ages of twelve and fourteen at Montcalm High School. The students were randomly placed in one of three groups. Each student participated in this study during the regularly scheduled school day. This study was limited to rural areas which were geographically and socio-economically similar.

Of the eighty-nine participants, forty-six (46) were females and forty-three (43) were males. All three groups took a pre-test without the use of calculators. The control group, which consisted of twenty-nine students, twelve females and seventeen males, took the post-test two weeks later without the use of calculators. Experimental group A was allowed to use calculators on the post-test but did not receive any instruction on how to use the calculator. There were thirty students, twenty females and ten males, in this group, who also took the post-test two-weeks after the pre-test. The third group had thirty students as well, fourteen females and sixteen males; however this group received calculator instruction and practice during the two weeks between tests. This group was called experimental group B.

Main Research Question

What is the effect of proper instruction in how to use calculators on the mathematics test scores of middle school students?

The following table shows descriptive statistics for each group on pre- and post-tests. The mean values and standard deviations were calculated to be compared and analyzed.

Table One

Comparative Mean Table

	X	SD	X	SD
	Pre-test	Pre-test	Post-test	Post-test
Exp Gp A	13.233	4.264	19.067	5.291
Exp Gp B	19.2	5.863	29.133	6.339
Control Gp	29.133	7.314	17.138	7.215

Sub-Hypotheses

There will be a significant difference between mathematics test scores of students who receive calculator instruction and those who do not use a calculator.

To show this, a t-test was performed comparing post-tests of experimental group B to the control group. The following table shows the results:

Table Two

t-Table

	t	α
Post Exp B vs Post Control	-6.319	0.0001

The t-test had an α-level of 0.0001 which indicated the t-value fell in the rejection region of the 2-tailed test. This means the null hypothesis is rejected and the alternate hypothesis is accepted. Clearly this states there was a significant difference between test scores of students who received calculator instruction and those who did not use a calculator.

A t-test was also performed comparing post-test scores of experimental group B to the pre-test scores of the control group.

Table Three

t-Table

	t	α
Post Exp B vs Pre-Control	-5.622	0.0001

Again this shows there was a significant difference between test scores of students who received calculator instruction and those who did not use a calculator.

There will be a significant difference between mathematics test scores of students who receive calculator instruction and those who have access to calculators with no instruction.

The following table shows the results of a t-test performed to compare the post-tests of experimental group B to experimental group A:

Table Four

t-Table

	t	a
Post Exp B vs Post Exp A	-6.728	0.0001

An α-level of 0.0001 here indicated a significant difference between test scores of students who received calculator instruction and those who used a calculator without instruction.

There will be a significant difference between mathematics test scores of students who have access to calculators and those who do not.

The following table shows the results of the t-test performed comparing groups who did not use calculators to those who had access but no instruction.

Table Five

t-Table

	t	α
Post Control vs Post Exp A	-0.972	0.3394

The α-level on this test showed there was not a significant difference between scores of students who had access without instruction and those who did not use calculators. An α-level greater than 0.025 does not fall in the rejection region; therefore the results indicated no significant difference.

The following table also shows the results of the t-test performed comparing groups who did not use calculators to those who had access but no instruction.

Table Six

t-Table

	t	α
Pre-Control vs Post Exp A	-0.251	0.8039

The α-level on this test showed there was not a significant difference between scores of students who had access without instruction and those who did not use calculators.

There will be a significant difference between pre- and post-test mathematics scores for students in experimental group A.

Table Seven shows the results of the t-test performed comparing scores of students in experimental group A. During the pre-test, these students were not allowed to use calculators but on the post-test were given access to them without instruction.

Table Seven

t-Table

	t	α
Pre- Exp A vs Post- Exp A	-6.341	0.0001

The results here indicated there was a significant difference in test scores for this group from pre-test to post-test.

There will be a significant difference between pre- and post-test mathematics scores for students in experimental group B who received calculator instruction for the post-test.

Table Eight shows the results of the t-test performed comparing scores of students in experimental group B. During the pre-test, these students were not allowed to use calculators but on the post-test were allowed to use them after two weeks of instruction on how to use them.

Table Eight

t-Table

	t	α
Pre Exp B vs Post Exp B	-8.827	0.0001

Clearly there was a significant difference between test scores after instruction with the calculators.

Table Nine shows the results of a t-test performed comparing scores of students in the control group. These students were not allowed to use calculators on the pre-test nor the post-test.

Table Nine

t-Table

	t	α
Pre-Control vs Post-Control	1.396	0.1737

Although the mean test scores decreased, there was not a significant difference indicated as a result of a t-test performed. The t-test had an α-level of 0.1737 which indicated the t-value did not fall in the rejection region of the 2-tailed test. Clearly this states there was not a significant difference between test scores of students in the control group from pre-test to post-test.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

This study involved eighty-nine seventh and eighth grade students at Montcalm High School. The students were randomly separated into three groups; one group had access to calculators but no instruction, a second group was given instruction on how to use the calculator, and a third group was the control group. All three groups took a pre-test without the use of a calculator. The control group took the post-test again without the use of a calculator. Both experimental groups took the post-test two weeks later with the use of a calculator but group B had instruction on how to use the calculators first.

The intent of this study was to determine if students' scores would improve more when teachers taught them how to use calculators rather than expecting them to know how to use calculators during testing situations. This study showed that students' scores did improve more with calculator instruction. A comparison of mean values as well as t-tests was performed to reach these conclusions. The design for this investigation was an experimental, three-group, pre-test/post-test design. The data was analyzed using a t-test of gain scores.

Conclusions

From the results of this study, it was concluded that students' test scores improved significantly when calculator instruction was given before testing situations. Just having calculators available did not impact student scores as

much as showing proper use and having them available. A comparison of mean values showed that the benefit of calculator instruction is greater than calculator use with no instruction. Comparing mean values also showed that using calculators, with or without instruction, produced higher scores than did no calculator use. On the post-tests, the group with no instruction had a mean value of 19.067 where the group with instruction had a 29.133 compared to the control group with a 17.138. The group with no instruction was only 1.929 points higher where the group with instruction was 11.995 points higher. Performing a t-test on the data also indicated a significant difference. An α-level of 0.0001, which resulted from a t-score of -6.728, was achieved when post-test scores of the group with instruction and the group without instruction were compared. This clearly indicated a significant difference in the test scores of these two groups. The scores of the control group decreased from pre-test to post-test but not significantly. An α-level of 0.1737, which resulted from a t-score of 1.396, was achieved when pre-test and post-test scores were compared.

Recommendations

A possibility for further research could include a comparison between males and females participating in the study. Another possibility may be to test long term usage of calculators and the effects on test scores. This study used a two-week instruction period. It would be interesting to conduct a year-long study, and also to administer a post-test without the use of calculators to determine if calculators help students learn and retain basic skills. Student attitudes about calculator use could also be explored and studied further. Further research could also be done to determine how calculator use affects different age groups.

While this sample was adequate for the purpose of this study, a larger sample might be advisable and may produce more general results. Further research is important on this subject in order that information can be gained on the most beneficial methods of achieving higher test scores and greater student success. With this knowledge, schools could restructure their curricula to incorporate calculators in more classes on a full-time basis. This could prove to be an asset to student achievement.

BIBLIOGRAPHY

Aronowitz, S. (1990). Science as poser: Discourse and ideology in modern society. University of Minnesota Press.

Battista, Michaie T. (1994). Calculators and Computers: Tools for Mathematical Exploration and Empowerment. Arithmetic Teacher, vol. 41, March.

Bitter, G. (1987). Educational technology and the future of mathematics education. School Science and Mathematics, pp. 87-465.

Boers-van Oosterum, M.A.M. (1990). Understanding of variables and their use acquired by students in traditional and computer- intensive algebra. Dissertation Abstracts International.

Bright, George W. and Prokosch, Neil E. (1995). Middle School Mathematics Teachers Learning to Teach With Calculators and Computers. School Science and Mathematics, vol. 95, October.

Caravella, Joseph R. (1977). Minicalculators in the Classroom. pp. 7-27.

Day, Roger. (1996). Classroom Technology: tool for, or focus for, learning? The Mathematics Teacher, vol. 89, no. 2, February.

Demana, Franklin and Waits Bert K. (1990). The Role of Technology in Teaching Mathematics. Mathematics Teacher. January.

Dick, Thomas P. (1992) Symbolic-Graphical Calculators: Teaching Tools for Mathematics. School Science and Mathematics, vol. 92, January.

Dickey, Edwin M. (1997). Challenges of Teaching Mathematics Today: How Can School Leaders Help? NASSP Bulletin, vol. 81, no. 586, February.

Dossey, John A. (1988). Use these questions to calculate the quality of your math instruction. The Ameican School Board Journal, August.

Drosdeck, Carola C. (1995). Promoting Calculator Use in Elementary Classrooms. Teaching Children Mathematics, vol. 1, no. 5, January.

Dunham, Penelope H. and Dick, Thomas P. (1994). Research on Graphing Calculators. The Mathematics Teacher, vol. 87, no. 6, September.

Fehr, Howard. (1988). A Philosophy of Arithmetic Instruction. Arithmetic Teacher, vol. 36, no. 3, November.

Forman, G. and Pufall, P. (1988). Constructivism in the Computer Age. Hillsdale, NJ: Lawrence Erlbaum.

Hamm, Mary. (1992). Achieving Scientific Literacy Through a Curriculum Connected with Mathematics and Technology. School Science and Mathematics, vol. 92, January.

Hamrick, Kathering B. and McKillip, William D. (1978). How Computational Skills Contribute to the Meaningful Learning of Arithmetic. Developing Computational Skills.

Hawthorne, Frank S. (1979) Hand-held calculators: help or hindrance? Calculators: Readings from the Arithmetic Teacher and the Mathematics Teacher, Bruce C. Burt, ED.

Immerzeel, George. (1979). The hand-held calculator. Calculators: Readings from the Arithmetic Teacher and The Mathematics Teacher. Bruce C. Burt, ED. pp. 5-6.

Jenson, R. J. and Williams, B. S. (1993) Technology: Implications for Middle Grades Mathematics. Research ideas for the classroom: Middle grades mathematics, D.T. Owens, ED. pp. 225-243.

Kenelly, John. (1990). Using Calculators in the Standardized Testing of Mathematics. Mathematics Teacher, December.

Kenny, Patricia Ann and Silver, Edward A. (1997). Results from the Sixth Mathematics Assessment of the Educational Progress, pp. 7-290.

Kloosterman, Peter and Cougan, Monica C. (1994). Students' Beliefs about Learning School Mathematics. The Elementary School Journal, vol. 94, no. 4, March.

Lehman, Jeffrey R. (1994). Technology Use in the Teaching of Mathematics and Science in Elementary Schools. School Science and Mathematics, vol. 94, April.

Mathematics Sciences Education Board (BMS). (1990). National Research Council. Reshaping School Mathematics, A Philosophy and Framework for Curriculum. pp. 2-26.

National Council of Teachers of Mathematics. (1989). Curriculum and Evaluation Standards for School Mathematics, Reston, VA; The Council.

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

Niess, Margaret L. (1993). Forecast: Changing Mathematics Curriculum and Increasing Pressure for Higher-Level Thinking Skills. Arithmetic Teacher, vol. 41, October.

Palmer, Henry B. (1979). Minicalculators in the Classroom -- What Do Teachers Think? Calculators: Readings from the Arithmetic Teacher and the Mathematics Teacher. Bruce C. Burt, ED.

Parker, Janet. (1992). Teaching Mathematics With Technology. Arithmetic Teacher, vol. 40, September.

Ratnesar, Romesh. (1997). This is Math? Time. vol. 150, no. 8, August.

Ross, Kenneth A. (1996). Mathematics Reform for K-16. Mathematics Teacher, vol. 89, October.

Rouse, J. (1988). Knowledge and power: Toward a political philosophy of science. Cornell University Press.

Ruthvan, K. (1990). The influence of graphic calculator use on translation from graphic to symbolic forms. Educational Studies in Mathematics. pp. 431-450.

Schielack, Jane F. and Dockweiler, Clarence J. (1992). Elementary Mathematics and Calculators: Let's Think About It. School Science and Mathematics, vol. 92, November.

Seitz, Sherilyn and Parks, Terry E. (1982). Calculators in Schools: Thoughts and Suggestions. Education in the 80's: Mathematics, Shirley Hill, ED. pp. 81-87.

Sheffield, Linda J. and Widmer, Connie C. (1994). Putting the Fun Into Functions Through the Use of Manipulatives, Computers, and Calculators. School Science and Mathematics, vol. 94, November.

Shumway, Richard J. (1979). Hand Calculators: Where Do You Stand? Calculators: Readings from the Arithmetic Teacher and The Mathematics Teacher. Bruce C. Burt, ED. pp. 7-10.

Smith, Karan B. and Shotsberger, Paul G. (1997). Assessing the Use of Graphing Calculators in College Algebra: Reflecting on Dimensions of Teaching and Learning. School Science and Mathematics, vol. 97, November.

Spangler, Denise A. (1992). Assessing Students' Beliefs About Mathematics. Arithmetic Teacher, vol. 40, November.

Suydam, Marilyn. (1982). Computation: Yesterday, Today and Tomorrow. Education in the 80's: Mathematics, pp. 36-44.

Suydam, Marilyn. (1979). The Use of Calculators in Pre-College Education. Calculator Information Center, Columbus, Ohio, May.

Thomasson, S. J. (1993). The effects of the graphing calculator on the achievement and attitude of college students enrolled in elementary algebra. Dissertation Abstracts International.

Usnick, Virginia E.; Lamphere Patricia; and Bright George W. (1995). Calculators in Elementary School Mathematics Instruction. School Science and Mathematics, vol. 95, January.

Waits, Bert K. and Demana, Franklin (1996). A Computer for All Students -- Revisited. The Mathematics Teacher, vol. 89, no. 9, December.

Wain, Geoffrey and Orton, Anthony, ED. (1994). Issues in Teaching Mathematics. pp. 2-209.

Weaver, J. Fred. (1981). Calculators. Mathematics Education Research: Implications for the 80's. Elizabeth Feunama, ED. pp. 154-171.

Willoughby, Stephen S. (1990). Why is Change Needed? Mathematics Education for a Changing World, pp. 3-70.

Wyatt, J. Wendell; Rybolt, James F.; Reys, Robert E.; and Bestgen, Richard. (1994). Status of Hand-held Calculator Use in School. Phi Delta Kappan. November.

SE062872

ERIC

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE

(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: A STUDY TO DETERMINE THE EFFECT OF INSTRUCTION IN EFFECTIVE USE OF A A CALCULATOR ON TEST SCORES OF MIDDLE SCHOOL STUDENTS.

Author(s): ROBIN PENNINGTON

Corporate Source: Salem Teikyo University
Benedum Library
Salem, WV 26426-0520

Publication Date:

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY Sample TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1	Level 2A	Level 2B
☑	☐	☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, → please

Signature: Robin Pennington	Printed Name/Position/Title: Robin Pennington	
Organization/Address:	Telephone: 304-248-7549	FAX: 304-589-7140
	E-Mail Address: robinpennington@hotmail	Date: 9-30-99

(over)

III. DOCUMENT AVAILABILITY INFORMATION (FROM NON-ERIC SOURCE):

If permission to reproduce is not granted to ERIC, *or*, if you wish ERIC to cite the availability of the document from another source, please provide the following information regarding the availability of the document. (ERIC will not announce a document unless it is publicly available, and a dependable source can be specified. Contributors should also be aware that ERIC selection criteria are significantly more stringent for documents that cannot be made available through EDRS.)

Publisher/Distributor:
Address:
Price:

IV. REFERRAL OF ERIC TO COPYRIGHT/REPRODUCTION RIGHTS HOLDER:

If the right to grant this reproduction release is held by someone other than the addressee, please provide the appropriate name and address:

Name:
Address:

V. WHERE TO SEND THIS FORM:

Send this form to the following ERIC Clearinghouse:

However, if solicited by the ERIC Facility, or if making an unsolicited contribution to ERIC, return this form (and the document being contributed) to:

ERIC Processing and Reference Facility
1100 West Street, 2nd Floor
Laurel, Maryland 20707-3598

Telephone: 301-497-4080
Toll Free: 800-799-3742
FAX: 301-953-0263
e-mail: ericfac@inet.ed.gov
WWW: http://ericfac.piccard.csc.com