Hand-held calculators in the mathematics classroom at Stuart Public School, Stuart, Nebraska

by Rodger William Lenhard

A thesis submitted in partial fulfillment of the requirements for the degree of DOCTOR OF EDUCATION
Montana State University

Abstract:
This study involved the use of hand-held calculators in the mathematics classes of Stuart Public School, Stuart, Nebraska, for one semester during the school year 1975-76. The mathematics classes included in the study were Math 7, Math 8, General Math, Business Math, Algebra I, Algebra II, Geometry and Trigonometry. The total number of students was 125. Each class was randomly divided into two groups and each group alternated using the calculator on at least eight standardized or teacher-made tests. After each test, an attitudinal test was administered to each student. A pre- and post-test were also administered to each student.

After a test in each class was completed, the data were tabulated on coding sheets and sent to Montana State University for analysis.

The data compiled on the coding sheet were Student Number, Test Number, Test Score, T score, Attitude Scale Scores, Test Date, Rank on the test, Number of Concept and Computation Errors, Whether or not a Calculator was used and the Length of time to take the test. The data were analyzed by t test, F test, Analysis of variance and Duncan's test. The level of significance was 0.05.

The hypotheses tested were those concerning test scores, concept and computation errors, attitudes, time and rank when students were experimental or control. Basically, the same hypotheses were tested with poorer students versus better students, and among the six grades, 7-12. Two topics discussed were test behavior and check of their work when students were experimental or control.

The findings of this study are explained below. There was no significant difference in the following areas when students were experimental or control: test scores, concept and computation errors, attitudes, time and rank. There was a significant difference in concept and computation errors and attitudes of the poorer students versus better students. There was also a significant difference in computation errors and time among the six grades, 7-12.

The topics of test behavior and checking were discuss-based on observation. There was nothing unusual related to test behavior and most of the time only better students checked their work.

The pre- and post-test scores were tested by the t test to the significance of H0: MeanPRE = MeanPOST, versus Ha: MeanPOST ≠ MeanPRE. The null hypothesis was accepted in Trigonometry and Geometry and rejected in Algebra I, Algebra II, Business Math and General Math. The same thing was done for grades 7-8, but their test was broken down into five basic tests: Concepts, Computation, Common Fractions, Decimal Fractions and Percent, and Number Facts. For Math 8, the null hypothesis was rejected on all five tests. For Math 7, the null hypothesis was rejected for Concepts, Decimal Fractions and Percent and Number Facts, and accepted for Computation and Common Fractions.

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AT STUART PUBLIC SCHOOL, STUART, NEBRASKA

by

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A thesis submitted in partial fulfillment
of the requirements for the degree

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ABSTRACT

This study involved the use of hand-held calculators in the mathematics classes of Stuart Public School, Stuart, Nebraska, for one semester during the school year 1975-76. The mathematics classes included in the study were Math 7, Math 8, General Math, Business Math, Algebra I, Algebra II, Geometry and Trigonometry. The total number of students was 125. Each class was randomly divided into two groups and each group alternated using the calculator on at least eight standardized or teacher-made tests. After each test, an attitudinal test was administered to each student. A pre- and post-test were also administered to each student.

After a test in each class was completed, the data were tabulated on coding sheets and sent to Montana State University for analysis. The data compiled on the coding sheet were Student Number, Test Number, Test Score, T score, Attitude Scale Scores, Test Date, Rank on the test, Number of Concept and Computation Errors, Whether or not a Calculator was used and the Length of time to take the test. The data were analyzed by t test, F test, Analysis of Variance and Duncan's test. The level of significance was 0.05.

The hypotheses tested were those concerning test scores, concept and computation errors, attitudes, time and rank when students were experimental or control. Basically, the same hypotheses were tested with poorer students versus better students, and among the six grades, 7-12. Two topics discussed were test behavior and check of their work when students were experimental or control.

The findings of this study are explained below. There was no significant difference in the following areas when students were experimental or control: test scores, concept and computation errors, attitudes, time and rank. There was a significant difference in concept and computation errors and attitudes of the poorer students versus better students. There was also a significant difference in computation errors and time among the six grades, 7-12.

The topics of test behavior and checking were discuss-based on observation. There was nothing unusual related to test behavior and most of the time only better students checked their work.

The pre- and post-test scores were tested by the t test to the significance of H_0: $\text{Mean}_{PRE} = \text{Mean}_{POST}$, versus H_a: $\text{Mean}_{POST} \neq \text{Mean}_{PRE}$. The null hypothesis was accepted in Trigonometry and Geometry and rejected in Algebra I, Algebra II, Business Math and General Math. The same thing was done for grades 7-8, but their test was broken down into five basic tests: Concepts, Computation, Common

Fractions, Decimal Fractions and Percent, and Number Facts. For Math 8, the null hypothesis was rejected on all five tests. For Math 7, the null hypothesis was rejected for Concepts, Decimal Fractions and Percent and Number Facts, and accepted for Computation and Common Fractions.

Chapter I

THE PROBLEM AND DEFINITIONS OF TERMS USED

It looks as if calculators are here to stay. If a person can rely on the advertising available, business seems to be booming.

> For more than a decade mathematics educators have been on notice that the day is approaching when everyone will have ready access to sophisticated electronic computers. Recent advances in the development of small, inexpensive calculators provide impressive support for the prediction. (Hawthorne, 1973:671)

According to William L. Gaslin, in an article in the Journal for Research in Mathematics Education, March, 1975:95, he states that an increasing number of mathematicians consider the calculator to be a beneficial and practical aid, both in the teaching and learning processes. It would appear to be a valuable motivating device. Due to this automatic age that we are in, the use of the calculator will make it more difficult to justify the amount of time we spend teaching mathematics.

Lois L. Beck conducted an experimental program in the Riverside City Schools in California, and arrived at the following conclusion:

> Besides stimulating children's interest and making arithmetic more meaningful, the use of the calculator seems to foster better work habits. It helps to develop habits of accuracy and neatness, wise use of time, checking work, attentiveness and concentration. It also helps students to follow oral and written directions, care for materials, and cooperate with others. The calculator, where I have observed its use, is regarded by the teachers as a valuable educational tool. The students look upon it with marked favor and enjoy the opportunity to use it. (Beck, 1960:103)

Gaslin also found in some of his research that there were conflicting viewpoints. [Some studies suggested that the use of calculators improves pupils' achievement in fundamentals when used for an extended period of time. However, a study by Johnson (1970), on rational numbers, indicated that the group without calculators scored significantly higher.] Another interesting finding in the study by Johnson was that the low or middle ability students using calculators displayed more positive attitudes towards mathematics than did those not using calculators.

After getting this topic approved by the graduate committee at Montana State University, the author approached the local School Board in Stuart, Nebraska, for their comments and suggestions. The School Board was very much in favor of the experiment. The next step was to approach the instructors of the mathematics classes for their consent to use their students. This was necessary because the author was the Superintendent of Schools and would not be teaching any classes. After receiving their approval, with no hesitation, the author was ready to prepare for and begin the experiment.

The instructions for using the calculators were given to each class by the author. These instructions were given to the teachers of the classes as well as to the students. The procedure followed was to go through the instructions manual step by step and to practice each step as we proceeded. Upon completing the instructions manual and doing some practicing with the calculators, the calculators were left in the classroom for the students and their teachers to use periodically. The experiment of using the calculators on tests in class began soon thereafter, whenever a test was scheduled.

I. THE PROBLEM

Statement of the Problem

The problem of this study was to determine whether the students in Mathematics in grades 7-12 at Stuart High School, Stuart, Nebraska, performed better on teacher-made tests and standardized tests after using hand-held calculators on the tests. The study also attempted to find out what changes may have occurred in the students' attitude towards mathematics as a result of having the opportunity to use calculators.

Purpose of the Study

It must be acknowledged that the hand-held calculators are becoming a part of life for many students today. Prices of calculators have decreased dramatically. Due to widespread inflation, continued lower prices are predicted. Leading companies are able to manufacture a four function memory calculator for less than five dollars. With these facts and knowing that 30 million calculators are now in use, teachers should plan carefully designed experimental programs for the hand calculator in the mathematics classrooms. (Dolan, 1975:1)

> [It should be first understood that the use of an electronic device does not eliminate the need for basic understanding of fundamental processes. Computation is and always will be important;] however, a new look at the importance of computational skill may be in order. The use of the calculator will have significant influence on the methods of instruction and the amount of time devoted to computation. (Dolan, 1975:1)

Questions to be Answered

It was the purpose of this study to try and answer various questions by conducting an experiment with the use of calculators in the mathematics classrooms in the Stuart Public School, Stuart, Nebraska, during the first semester of the school year, 1975-76. Each mathematics class, grades 7-12, was divided into two groups, experimental and control. These two groups then alternated using calculators on the tests administered in each class. Following each test an attitudinal test was given to the students. The data taken from each test and from each attitude test were tabulated and used to answer the following questions.

GENERAL QUESTIONS:

1. Was there a change in attitude towards mathematics of the students after using a calculator?

2. Was there a change in the performance of concepts of the students after using a calculator?

3. Was there a change in the performance of computation of the students after using a calculator?

SPECIFIC QUESTIONS:

1. Were the test scores higher among the students who used a calculator (experimental) than those who did not use a calculator (control)?

2. Was the performance with concepts better when the students were experimental or when they were control?

3. Was the performance with computation better when the students were experimental or when they were control?

4. Was the attitude of the students better when they were experimental or when they were control?

5. Did the students finish the tests in a shorter period of time when they were experimental or when they were control?

6. Was there a difference in test behavior when the students were experimental or when they were control?

7. How did the work of the lower grade students using the calculators compare to the work of the upper grade students using the calculators?

8. Was there a difference in performance of concepts between poorer and better students when they used calculators?

9. Was there a difference in performance of computation between poorer and better students when they used calculators?

10. Was there a difference in attitudes between poorer and better students when they used calculators?

11. Was there a difference in ranking of the students between the test scores when they were experimental and when they were control?

12. Did the students check their work more when they were experimental or when they were control?

Limitations and/or Delimitations

This study was limited to the students in the mathematics classes, grades 7-12, at Stuart Public School, Stuart, Nebraska. Also, the experiment was done with the very basic hand-held calculators.

II. DEFINITIONS OF TERMS USED

Calculators

The machine used in this study were the small, hand-held calculators. The calculators used were the APF Mark 26 electronic hand-held calculator made by APF Electronics, Inc., New York, New York. The machine had the four basic functions; addition, subtraction, multiplication, division, a percentage key and one memory. Throughout this study they were referred to as just calculators.

Performance

This term was used to imply how well the students did from time to time on their mathematics work.

Tests

The tests used and referred to in this study were the standardized tests that accompany the course texts, if available. Otherwise, carefully constructed teacher-made tests were used.

Attitude

Oppenheim suggests that the following be used as a definition of attitude:

> An attitude is a state of readiness, a tendency to act or react in a certain manner when confronted with certain stimuli. (Oppenheim, 1966:105)

In this study, attitude was operationally defined by an attitude scale developed by Aiken and Dreger and found in the book by Shaw and Wright entitled Scales for the Measurement of Attitudes. The two people who developed the scale report a test-retest reliability coefficient of .94. (Shaw and Wright, 1967:242)

III. SUMMARY

The problem of this study was to determine whether students performed better after using calculators in mathematics classes during the school year for one semester. Also, does a student's attitude toward mathematics change after using a calculator?

[The use of calculators does not really eliminate any phase of mathematics. It will, no doubt, shorten the computation processes. Yet, a student will still need to know the fundamentals of mathematics.]

Chapter I indicates what is to be done in this study. There are general questions, as well as specific questions, to be answered after the study is complete. These questions are listed in Chapter I, but will be answered in a later chapter.

Chapter II

REVIEW OF RELATED LITERATURE

The structure of this chapter will be to discuss some studies done on new innovations in mathematics, then to discuss some studies related to attitudes towards mathematics, and finally to discuss the main idea of this study; that being the use of hand-held calculators.

INNOVATIONS IN MATHEMATICS

The first portion of this chapter is devoted to new ideas, or innovations, in mathematics. Because the hand-held calculator is new to the field of mathematics, the author would like to discuss other innovations that relate to mathematics. The first topic to be discussed will be television, followed by unipacs, children's literature, retesting and lastly, mathematics laboratories.

Television broadcasts in the mathematics classroom appear to be more prevalent than they used to be. John Cain (1965:41) stated that, "television was really introduced to the schools in the United Kingdom in 1957." However, according to Cain,

> 1965 was the big year when there were produced 170 mathematics programmes in six series aimed at the primary school, the secondary modern school, and the grammar school, as well as 20 special programmes for mathematics teachers.

The main reasons for the series of programs that were produced, stated Cain (1965:41) were, to incorporate new areas that would require visual interpretation; to bring in new areas of mathematics in which they were unfamiliar; to bring more mathematics to the understaffed school; and to keep people informed of new ideas in mathematics.

The following points are stated by Cain (1965:48) as discussion topics for the future of television in mathematics. They are condensed somewhat but still include the main thoughts.

i) The most urgent task is to explore fresh and lively mathematical ideas.

ii) There is a constant search for able television presenters to be used to improve the quality and quantity of teaching in schools.

iii) Efforts should be concentrated on areas that are most needed, but what are these areas?

iv) Mathematics is an abstract discipline, but it grew up and grows in a social setting where it is "used."

v) How can we achieve most pupil participation?

vi) What is the best length of a program and how often should programs be broadcasted?

vii) Is there a case for preservation of films or film-loops?

viii) Mathematics tends to be more abstract and non-visual in its essence, therefore, teachers have to re-think it in visual terms.

There are definitely some advantages to using television in the teaching of mathematics. In an article by James Montgomery entitled, "The Use of Closed Circuit Television in Teaching Junior High Mathematics," in School Science and Mathematics, November, 1969, Vol. LXVIII, No. 8, Whole 604, 747-48, the objectives are clearly stated.

Proper use of the media will bring about more effective use of teacher time by relieving them of some of the preparation and responsibility for major informational presentations and redirecting their efforts toward meeting the individual needs of students. The quality of lesson presentations will improve through increased cooperative planning among involved teachers and substantial time to study and prepare for the television teacher. The educational experiences of students will be expanded by utilizing outside talent, capitalizing upon the special interests and achievements of teachers, and having students prepare programs. Through observations of televised lessons a classroom teacher will be able to assess his performance by comparing it with that of his colleagues.

Richard D. Pethtal (1968:521) conducted a study at Indiana State University on college level mathematics and television and stated the following two conclusions,

> First, that students in television courses achieve well and retain as much as those in lecture courses, and secondly, television instruction effects student achievement at different ability levels.

The second innovation to be discussed in this chapter is the use of unipacs in teaching high school algebra. A study was done in Joint School District 3, Middleton, Wisconsin, by Earl Lochner, Gerald Mrochek and James Lackore. (1973:201) They concluded that,

> As a result of this experience, we have tentatively concluded that, while most of our students made acceptable progress in learning algebra, unipacs are not equally effective learning tools for all students. We observed that most of our students who were able to manage their time and work on their own performed satisfactorily. These students enjoyed having the opportunity to plan their own work schedules and to learn more if they so desired. On the other hand, the students who drift, become discouraged, fall behind and lose interest. The net result was that we had improved our instructional program for the self-directed students, but had made little progress in helping the marginally motivated students who were primarily dependent on teacher-imposed structure.

Another interesting innovation was the use of children's literature in mathematics instruction. Lucille B. Strain (1969:451) stated, "helping children develop clear, correct concepts in mathematics is a major task for teachers in elementary schools." Strain also stated,

> The content of many literary selections, whether obviously or subtly mathematical in nature, however, offers advantages for clarifying, strengthening, and extending children's concepts in mathematics.

Strain gives the following as mathematics topics that relate to children's literature, "Numbers and Numerals, Addition, Subtraction, Multiplication, Division, Measurement, Time, Quantitative Terms, Space Concepts, Problem Solving, Geometric Concepts and Money."

A fourth innovative method is that of retesting as a teaching device. Marc D. Glucksman (1973:725) said, "that learning depends on a mastery of learned skills and this may be done by retesting."

In the study done at El Camino College in Via Torrance, California, Glucksman (1973:725) stated the following hypothesis as the basis of the study:

> The achievement of students who are allowed to retest on course objectives does not differ from the achievement of students who do not retest with respect to mean scores on a standardized final algebra test and an instructor-prepared final algebra test.

Glucksman summarized by saying, "the retesting system proved as effective a teaching device as a nonretesting system."

The next and last mathematics innovation to be discussed in this chapter is that of the mathematics laboratory. Mathematics laboratories are not a new concept in the education field. In an article by

Larry K. Johnson, entitled "The Mathematics Laboratory in Today's Schools," School Science and Mathematics, November, 1962, Vol. LXII, No. 8, p. 586, it is stated that, "labs date back to the early 1900's." In this article Johnson quotes William David Reeve as saying, "Although teachers of mathematics have been slow to transform their recitation rooms into laboratories and workshops, this is what really needs to be done to insure proper use of multisensory aids in teaching." Johnson asked, "Why has such a method so long been ignored by mathematics teachers?" He answered this question by saying, "the lack of familiarity with application of laboratory principles in the mathematics classroom by the normal mathematics teacher."

Edwina Deans in Today's Education, February, 1971, Vol. LX, No. 2, pg. 20-22, states,

> The laboratory approach exposed children to a wide range of manipulative, concrete materials, and practical activities from which they can abstract mathematical ideas.

Brousseau (1973:100) stated the following as characteristics of the laboratory approach:

> 1. Relates learning to past experience and provides new experiences when needed.
> 2. Provides interesting problems for the students to investigate.
> 3. Provides a non-threatening atmosphere conducive to learning.
> 4. Allows the student to take responsibility for his own learning and to progress at his own rate.

ATTITUDINAL STUDIES

A study was done in Lafayette Parish School System, Lafayette, Louisiana, relating the effect of programmed lectures and games upon achievement and attitude of low achievers in mathematics. Thomas Jones (1968:606) stated that the hypothesis, "was to test the attitude of these students contrasting experimental classroom attitudes to previous classroom attitudes." The study was conducted during a summer school session with 38 students ranging from 15 to 17 years of age. Jones said, "there was a positive attitude toward the summer session and the instructional method used."

Jonathan Knaupp (1973:9-11), in an article entitled, "Are Children's Attitudes Toward Learning Arithmetic Really Important," School Science and Mathematics, January, 1973, Vol. LXXIII, No. 1, Whole 642, includes a brief summary of many studies related to attitudes toward mathematics and learning. Knaupp stated many conclusions of various authors in this article. The author of this paper would like to share many of the comments taken from Knaupp's article.

Fisbein (1967) said, "that knowledge of an individual's attitude toward some object does not allow one to predict the way he will behave towards the object."

Dobb (1967) said, "that attitude and behavior could be unrelated since, just as attitude is learned so is the corresponding response."

Neal (1969) "is not sure that scientific study verifies the claim that favorable attitude toward school subjects maximize the willingness to learn more. He also states, "that given the present nature of schools, children do not have the opportunity to let their attitudes influence their learning."

Fedon (1958) has inferred from his studies, "that children are already forming opinions about mathematics by the third grade."

Poffenberger and Norton (1956) point out, "that attitudes toward mathematics are a result of many factors, including home background and previous experiences."

Lastly, Mager (1966) stated, "that circumstances surrounding the learning experience influence the learning attitude."

Jonathan Knaupp summarizes by saying,

> a major need at this time is an accurate attitude measuring device for young children that can be used by teachers in classroom situations. Using such an instrument, additional research can be done to determine the causal relationship of attitudes and learning arithmetic, and factors that influence students' attitudes.

Daniel Neale (1969:631) insists that "mathematics educators are troubled because many students have mistaken impressions about mathematics and dislike mathematical activities." He also feels, "that discovery modes of learning and mathematical recreations develop a positive attitude toward mathematics." Neale stated that attitude plays an important role in learning mathematics."

Donald F. Devine (1968:300), in, "Student Attitudes and Achievement: A Comparison Between the Effects of Programmed Instruction and Conventional Classroom Approach in Teaching Algebra I," The Mathematics Teacher, March, 1968, Vol. LXI, No. 3, discusses a study done in the Rich Township High Schools located in Park Forest and Olympia Fields, Illinois. Devine indicated that the findings of the study suggest that,

> 1. The achievement of students who study with an average or above-average teacher using a textbook and the usual classroom techniques is significantly better than is that of students using programmed material.
> 2. The achievement of students who are working with an inexperienced teacher or a below-average teacher will be as good using programmed materials as with the usual classroom teaching approach.
> 3. Student attitudes towards mathematics are not affected by the approach used when the students are under the direction of an average or above-average teacher.
> 4. Attitudes towards programmed materials are not significantly decreased by using these materials for the duration of one year if the teacher involved is an average or above-average teacher.
> 5. Attitudes towards mathematics and toward programmed materials seem to be affected negatively by an inexperienced teacher.
> 6. Teacher reaction to the use of programmed materials was found to be quite negative, although the use of programmed materials under certain special circumstances was recommended.

HAND-HELD CALCULATORS

Jackson B. Sosebee, Jr. and Lola Mae Walsh (1975:324) stated,

> Within the last few years, the use of pocket electronic calculators by students has increased dramatically. Various institutions have responded to this phenomenon in different

ways, some by prohibiting their use in examinations, some by encouraging their use and others by considering them a student option. In virtually no cases, however, have institutional decisions been based on experimentally derived data.

The results of a study at the University of Montana, Fall Quarter, 1973, by Sosebee and Walsh, are indicated below:

> It appears that calculators play a major role in the determination of introductory Chemistry grades. The remedies are not as apparent, however. Two previous answers to the problem are to either prohibit their use or to make them available to all students. Many teachers would consider their prohibition archaic, but providing them to all students may not be economically feasible at this time. A better approach might be to design examinations with the knowledge that using a calculator provides a clear advantage to those who have access to them. Specifically, arithmetic operations in problems might be reduced, the number of problems might be limited to allow persons using slide rules to check their calculations, or the number of points deducted for arithmetic errors in the problems might be minimized.

William D. Smith, in the New York Times, August 20, 1972, mentions a few more incidences where hand-held calculators are being used. He stated, "the use ranges from the fourth grade, through the college level, and definitely into business." Smith also states in this article, "A gadget or a useful tool? The hand-held calculators appear to be both."

There was an article in The Arithmetic Teacher, October, 1956, that reported the results of an experiment where hand-operated computing machines were used in learning arithmetic. The experiment was learning multiplication by the use of machines. The experiment was designed to test whether or not the use of the hand-operated calculators would aid in learning the meaning and understanding as well as developing computation. Howard Fehr, George McMeen and Max Sobel (1956:145-6) found that, "no significant difference was found favoring control group or experimental group; i.e., those not using machines versus those using machines. These three authors found three advantages to using the machines. They were,

> . . . the enjoyment of the pupils who used the machines; the experience of using the machines; and, the gain in learning by those who used the machines with the paper and pencil method.

The experiment was then conducted for 4½ months, compared to the two-week experiment earlier, to hopefully make a more satisfactory test. According to Fehr, McMeen and Sobel (1956:148-9), the experiment tested one hypothesis:

> Pupils who use computing machines to learn arithmetic will gain significantly in paper and pencil computations, and in arithmetic reasoning over those who do not use the computing machines.

The authors stated, "a significant gain in both computation and reasoning on the part of the experimental group." In conclusion, the authors stated, "that machine taught students gain more in computation, reasoning, learn more and their interest is heightened."

Schanghency (1955:21) had the feeling that, "get a child to like a subject and no doubt he would do better in it." He also insisted that, "the machine was an interest catcher and was used as a checking device."

Joseph Cech (1972:183), in a study done in Park Ridge, Illinois, stated the following hypotheses:

> 1. The use of calculators in the instructional program with ninth grade, low-achieving mathematics students improve their attitude toward the study of mathematics.
> 2. The use of calculators in the instructional program with ninth grade, low-achieving mathematics students improves their computational skills.
> 3. Ninth grade low-achieving mathematics students can compute better with calculators than without calculators.

Cech stated the results as being, "no change in attitudes, no change in computational skills, but that low-achievers could compute better with calculators than without." He also felt that, "an experiment for a longer period of time than seven weeks may improve their attitudies towards mathematics as well as improve their computational skills."

In Math Teacher, Summer, 1965, pg 12, an article by J. Denniss was written dealing with calculators with seven and eight year olds. To summarize, Denniss said that the aims were to find out if, "students could handle the machine and what effect the machines would have on their attainment levels in arithmetic." Briefly, the results of the study were, according to Denniss (1965:13-14), "the machines were used quite easily; students were delighted to work large numbers; the basic operations were enforced; marked improvement in attainment; and, the calculators were an interest catcher as well as a confidence builder." Patricia M. Hopkins (1965:14) stated in an article that she wrote that, "the girls were interested but the boys thought they were playthings." Hopkins did this study in the remedial classroom and summarizes by saying, "the whole attitude towards mathematics has changed. It is now something to be enjoyed, not feared; looked forward to, not dreaded."

A paper presented at the Canadian Conference on Educational Research, entitled, "Desk Calculators in the Mathematics Classroom," by F. R. Longstaff and others (1968:7), stated the following conclusion:

> It becomes clear then why desk calculators are recommended for use by slow learning students. They fit into the environment of the classroom and make the period more enjoyable for the students. In addition, they give the appearance of increased productivity and efficiency among students who have not previously been noted for these traits. In general, the classroom confrontation between student and teacher is made more orderly, resulting in an atmosphere of less stress for both parties. These are important functions and in performing these, the machines serve a useful purpose. The functional importance of the innovation, however, lies in its potential as a toy rather than as an aid to learning. As such, it is unlikely that desk calculators will be an educational innovation of any permanence; real toys cost considerably less.

At Peabody Demonstration School in Nashville, Tennessee, there was a study that investigated the effect of calculators on arithmetic achievement in grades six, seven and eight. Thirty-five pairs of students were matched on intelligence and achievement measures and randomly assigned to experimental and control groups. The experimental groups used calculators for approximately thirty minutes each school day for a period of nine weeks. In this study, Durrance (Eric report, 1964:46) stated,

> Analysis of the data resulted in no significant effects of the calculator on arithmetic achievement. However, it did result in significant differences between experimental and control groups on a test of reasoning in the seventh grade. This points out the need for further research on dependent variables such as problem-solving and reasoning ability.

SUMMARY

This chapter gives some background information on the use of calculators and some studies that refer to calculators. We see that there are some advantages as well as disadvantages to the use of calculators. Also, there are some studies referred to in this chapter related to other mathematical innovations besides calculators. The study by the author with the use of calculators in the classroom also relates to students' attitudes. In this Review of Literature Chapter some studies are cited about attitudes and mathematics.

Chapter III

METHOD OF PROCEDURE

The material in this chapter describes the contents of the study. The population description and sampling procedure is described as well as the types of tests used. The data obtained from this study were collected and organized to answer the questions and hypotheses stated. Analysis for this study was based on the computer and the calculator.

POPULATION DESCRIPTION AND SAMPLING PROCEDURE

The experiment involved students in the mathematics classes at Stuart Public School, Stuart, Nebraska, for one semester during the school year, 1975-76. The students were in grades 7-12 and the total number of students was 125. The population was distributed as follows:

Math 7	=	29 students
Math 8	=	26
General Math	=	19
Algebra I	=	21
Business Math	=	15
Algebra II	=	3
Geometry	=	10
Trigonometry	=	2
TOTAL	=	125 students

The total population was exposed to the hand-held calculators during the first week of the school year, 1975-76. During each class period of the first week of school the students were exposed to the topics of mathematics pertaining to their class. The last few minutes of their class period were used to introduce the calculators. During the second week of school, students could practice the use of the calculators whenever they had some free time in class. Each mathematics class in the Stuart Public School system, grades 7-12, was rancomly divided into two groups, Group I and Group II, and alternated throughout the study as experimental and control. In case of an odd number of students in a class, Group I included this person and was one person larger than Group II.

As was stated each mathematics class was randomly divided into Group I and Group II. For the first mathematics test in each class, Group I was considered experimental while Group II was control. For the second mathematics test Group I became the control group and Group II became the experimental group. This method of alternating groups as experimental and control continued as the tests were given in each mathematics class. This study was conducted for one semester of the school year, 1975-76, and there were eight to ten tests given in each class depending on the mathematics class in which they were enrolled.

PROCEDURES FOLLOWED

Data for this study were collected and analyzed according to the procedures described in this section.

Method of Collecting Data

At the beginning of the study, a standardized pre-test measuring mathematical concepts and computation was administered to the students. The test administered to grades 7-8 was the Stanford Diagnostic Arithmetic Test, Level II, Form W. This test was broken down into five subtests. They were Concepts, Computation, Common Fractions, Decimal Fractions and Percent, and Number Facts. The reliability coefficients and standard errors of measurement for the above tests for grades 7-8 are listed in the following table.

Table 1. Reliability Coefficients and Standard Errors of Measurement for Subtests, Grades 7-8

Test	Grade 7		Grade 8	
	Rel.	SE_m	Rel.	SE_m
Concepts	.93	2.4	.92	2.7
Computation	.92	2.5	.90	2.3
Com. Fractions	.98	1.8	.97	2.1
Dec. Fr. & Percent	.92	2.3	.93	2.4
Number Facts	*	*	*	*

*Distribution of scores on the Number Facts subtests are so skewed in most cases that the reliability coefficients and standard errors of measurement for them do not seem to be useful. (Beatty, Madden, Gardner, 1966)

The validity reported for the above tests relates each test to Arithmetic Computation, Arithmetic Concepts and Arithmetic Applications. The following table relates this information.

Table 2. Validity Report for Subtests, Grades 7-8

Test / Grades	Arith. 7	Comp. 8	Arith. 7	Con. 8	Arith. 7	App. 8
Concepts	.62	.72	.62	.80	.53	.77
Computation	.61	.68	.42	.56	.37	.58
Com. Fractions	.72	.68	.61	.68	.62	.68
Dec. Fr. & Percent	.65	.59	.66	.73	.60	.74
Number Facts	NO INFORMATION GIVEN					

The pre-test administered to grades 9-10 was the Stanford Tests of Academic Skills, Level I. The pre-test administered to grades 11-12 was the Stanford Tests of Academic Skills, Level II. The reliability, validity and standard error of measurement are given in the following table.

Table 3. Reliability, Validity and Standard Errors of Measurement for Stanford Tests of Academic Skills, Grades 9-12

Grade	Rel.	Val.	SE_m
9	.94	.67	2.8
10	.95	.71	2.6
11	.94	.57	2.9
12	.94	.59	2.8

Upon completing the study, a post-test using the same instrument as the pre-test was administered and these scores were used in comparison with the pre-test scores. These scores were compared by a t test of independent samples to see if there was a significant increase of the post-test scores over the pre-test scores.

Standardized or teacher-made tests were the types of tests that the teachers chose to use in their mathematics classes. Therefore, standardized or teacher-made tests were used in the mathematics classes as the basis for this study. Standardized tests were used in Algebra I, Geometry, General Math and Business Math as they accompanied the texts. Teacher-made tests were used in Math 7, Math 8, Algebra II and Trigonometry. Following each test in each class, data were compiled on coding sheets to be sent to the computer center at Montana State University for analysis. Following is a list of items that was included on the coding sheet:

1. Student Number (includes grade)
2. Test Number
3. Test Score (raw score)
4. T Score
5. Attitude Scale Scores (ranked 0, 1, 2, 3, 4)
6. Test Date
7. Rank on the Test
8. Number of Concept Errors
9. Number of Computation Errors
10. Whether or not a Calculator was used on the test
11. Length of time to take the test in minutes

A second area of concern in this study was students' attitudes toward mathematics. An attitude test was administered to each student after each mathematics test was given in class. The attitude scale used was one developed by Aiken and Dreger found in the book by Shaw and Wright entitled, Scales for the Measurement of Attitudes. The test was a 20 statement instrument with five choices for each statement. The scale had a test-retest reliability coefficient of .94. (Shaw and Wright, 1967:242)

The author was interested in finding out if students would check their own work when they used calculators. The author felt that the only way a reasonable decision could be reached was by observation of the students as they took their tests in each class. Since the author could not find a test available to analyze their checking statistically, observation seemed to be the best method.

Another concern was that of test behavior of the students as they took their tests. Were there any unusual reactions by the students during the testing periods? Again, since the author could not find a test available to analyze test behavior, observation was the method used.

Method of Analyzing Data

After the experiment was completed, the data were compiled on coding sheets and sent to Montana State University for analysis. The t test of independent samples was used to analyze the means of the distributions while the F test was used to analyze the variances of the distributions. These two tests were used to test the hypotheses involving two groups; experimental and control and poorer students versus the better students. An F test from the Analysis of Variance was used to test hypotheses of significance among the six grades, 7-12. This type of analysis was used because there were more than two groups to be tested. To further explain a significance when found in the Analysis of Variance, the Duncan's test for multiple comparisons was used.

Hypotheses

The following hypotheses, in particular, were tested on the basis of the data received from the study.

1. There is no significant difference in test scores when students are experimental or control.

2. There is no significant difference in the number of concept errors when students are experimental or control.

3. There is no significant difference in the number of computation errors when students are experimental or control.

4. There is no significant difference in attitudes of students toward mathematics when they are experimental or control.

5. There is no significant difference in the time it takes to finish a test when students are experimental or control.

6. There is no significant difference in the rank of students when they are experimental or control.

7. There is no significant difference in the number of concept errors of the poorer students versus the better students.

8. There is no significant difference in the number of computation errors of the poorer students versus the better students.

9. There is no significant difference in attitudes of the poorer students versus the better students.

10. There is no significant difference in concept errors of the poorer students when they are experimental or control.

11. There is no significant difference in computation errors of the poorer students when they are experimental or control.

12. There is no significant difference in attitudes toward mathematics of the poorer students when they are experimental or control.

13. There is no significant difference in test scores among the six grades, 7-12.

14. There is no significant difference in the number of concept errors among the six grades, 7-12.

15. There is no significant difference in the number of computation errors among the six grades, 7-12.

16. There is no significant difference in the time it takes to finish a test among the six grades, 7-12.

Method of Computing Results

The statistics that were computed on the basis of the data compiled were done by the computer at Montana State University and the hand-held calculator. The computer was used to test the 16 hypotheses above related to experimental or control, poorer students versus better students and those among the six grades, 7-12. The hand-held calculator was used to test the significance of the post-test scores related to the pre-test scores.

Check of Accuracy

The 16 hypotheses were tested by t tests and/or F tests. The t values and F values given on the computer printouts were spot checked by the author with a hand-held calculator. The t test results for the post-test scores compared to the pre-test scores were checked by repetition on the hand-held calculator.

SUMMARY

The population of students used in this study was 125 students in the mathematics classes, grades 7-12, in Stuart Public School, Stuart, Nebraska. The experiment was conducted for 18 weeks, during the school year 1975-76. The mathematics classes were randomly divided into two groups, experimental and control, and these groups alternated using calculators on the tests administered in their mathematics classes. An attitudinal test, developed by Aiken and Dreger, was administered to each student after each test. The Stanford Diagnostic Arithmetic Test, to grades 7-8, and the Stanford tests of

Academic Skills, to grades 9-12, was administered as a pre-test and post-test.

The data gathered from the tests in each class were compiled on coding sheets and analyzed by the computer at Montana State University. Hypotheses that were tested were concerned with test scores, concept and computation errors, attitudes, time and rank. The hypotheses were tested for experimental and control groups, poorer students versus better students, poorer students as experimental and control, and for significance among the six grades, 7-12.

Chapter IV

ANALYSIS OF DATA

This study involved 125 students in the mathematics classes, 7-12, in Stuart Public School, Stuart, Nebraska. Each class was randomly divided into two groups and alternated using calculators throughout the study, as experimental and control. Calculators were used on the major tests given in each mathematics class for one semester. Math 7 class was given 10 tests, Math 8 class was given nine tests, while General Math, Algebra I, Geometry, Business Math, Algebra II and Trigonometry classes were each given eight tests. Taking the number of students in each class, multiplied times the number of tests in each class and adding these numbers together gives us the total number, N, of the entries used for analysis; N=1084.

DEFINITION OF TERMS

In order to better understand the study, the following definitions are stated.

Experimental

This term refers to those students that used calculators on a test. This was 542 or 1084 divided by two.

Control

This term refers to those students that did not use calculators on a test. This was also 542 or 1084 divided by two.

Poorer Students versus Better Students

The students' test scores were converted to T scores after they completed each test. T scores are normally distributed, usually with a mean of 50 and a standard deviation of 10. With this idea as a basis, students were classified as poorer students if their average T score was less than 45 and better students if their average T score was greater than 55. This left a certain amount of students in an area one-half standard deviation above and below the mean of 50. This group of students was not used in the hypothesis testing. The group of students being experimental, N=542, was divided into poorer students, N=175, better students, N=201, and those one-half standard deviation above and below the mean, N=166. The N's for poorer and better students were used when testing the hypotheses related to these students.

ANALYSIS OF DATA

The data for this study were compiled on coding sheets and the sheets were sent to Montana State University for analysis. The information was entered into the computer and analyzed by the t test, F test of Variances, Analysis of Variance and Duncan's test of multiple comparisons if a significance was found in the Analysis of Variance. The results are described in this chapter. Below is a list of items that were included for each student on each test that was given throughout the study:

1. Student Number (includes number)
2. Test Number
3. Test Score (raw score)
4. T Score
5. Attitude Scale Scores (ranked 0, 1, 2, 3, 4)
6. Test Date
7. Rank on the Test
8. Number of Concept Errors
9. Number of Computation Errors
10. Whether or not a Calculator was used on the test
11. Length of time to take the test in minutes

The hypotheses stated for this study were all tested statistically. The level of significance used in each case was five percent. There were two topics of concern that were reported in this study based on the author's observation. They were that of test behavior when using calculators and checking the work when using a calculator. Because there seemed to be no real test statistically that could be used for these two items, they were not put in hypothesis form.

Testing Hypotheses, 1-9

The major portion of this chapter to follow is the analysis of the hypotheses. Each null hypothesis has been stated and the statistic used for determining the significance of the difference found is indicated. This is followed by a decision whether to accept or reject the null hypothesis and a table illustrating the statistics used.

Null Hypothesis #1: There is no significant difference in test scores when students are experimental or control.

Statistics:	Critical t=1.96	D.F.=1082
	Computed t=0.07767	D.F.=1082
	Critical F=1.16	D.F.=541, 541
	Computed F=1.04057	D.F.=541, 541

Decision: Accept the Null Hypothesis

Table 4. There is no significant difference in test scores when students are experimental or control

*	N	Mean	Sigma	Variance	F	4	D.F.
1	542	49.80074	10.26569	105.38446	1.04057	0.07767	1082
2	542	49.84869	10.06357	101.27541			

*1=Experimental 2=Control

Null Hypothesis #2: There is no significant difference in the number of concept errors when students are experimental or control.

Statistics:	Critical t=1.96	D.F.=1082
	Computed t=0.63355	D.F.=1082
	Critical F=1.16	D.F.=541, 541
	Computed F=1.07143	D.F.=541, 541

Decision: Accept the Null Hypothesis.

Table 5. There is no significant difference in the number of concept errors when students are experimental or control

*	N	Mean	Sigma	Variance	F	t	D.F.
1	542	3.55350	3.75550	14.10340	1.07143	0.63355	1082
2	542	3.41140	3.62810	13.16310			

*1=Experimental 2=Control

Null Hypothesis #3: There is no significant difference in the number of computation errors when students are experimental or control.

Statistics: Critical t=1.96 D.F.=1082
Computed t=0.38938 D.F.=1082
Critical F=1.16 D.F.=541, 541
Computed F=1.12818 D.F.=541, 541

Decision: Accept the Null Hypothesis

Table 6. There is no significant difference in the number of computation errors when students are experimental or control

*	N	Mean	Sigma	Variance	F	t	D.F.
1	542	7.29700	6.80750	46.34230	1.12818	0.38938	1082
2	542	7.46310	7.23070	52.28239			

*1=Experimental 2=Control

Null Hypothesis #4: There is no significant difference in attitudes of students toward mathematics when they are experimental or control.

Statistics: Critical t=1.96 D.F.=1082
Computed t=0.38423 D.F.=1082
Critical F=1.16 D.F.=541, 541
Computed F=1.02236 D.F.=541, 541

Decision: Accept the Null Hypothesis.

Table 7. There is no significant difference in attitudes of students toward mathematics when they are experimental or control

*	N	Mean	Sigma	Variance	F	t	D.F.
1	542	62.15866	15.32862	234.96672	1.02236	0.38423	1082
2	542	61.79889	15.49909	240.22180			

*1=Experimental 2=Control

Null Hypothesis #5: There is no significant difference in the time it takes to finish a test when students are experimental or control.

Statistics: Critical t=1.96 D.F.=1082
Computed t=1.04076 D.F.=1082
Critical F=1.16 D.F.=541, 541
Computed F=1.07738 D.F.=541, 541

Decision: Accept the Null Hypothesis.

Table 8. There is no significant difference in the time it takes to finish a test when students are experimental or control

*	N	Mean	Sigma	Variance	F	t	D.F.
1	542	26.91512	11.79745	139.17987	1.07738	1.04076	1082
2	542	26.15497	12.24542	149.95042			

*1=Experimental 2=Control

Null Hypothesis #6: There is no significant difference in the rank of students when they are experimental or control.

Statistics: Critical t=1.96 D.F.=1082
Computed t=0.02857 D.F.=1082
Critical F=1.16 D.F.=541, 541
Computed F=1.00453 D.F.=541, 541

Decision: Accept the Null Hypothesis.