AN ANALYSIS OF THE EFFECT OF THE USE OF

A HAND-HELD CALCULATOR ON ATTITUDE

AND ACHIEVEMENT IN SELECTED

COLLEGE ALGEBRA CLASSES

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CHAPTER I

PROBLEM STATEMENT

Background Information

Improvements in technology, manufacturing processes and marketing applications have led to the introduction of low-cost hand-held calculators. They are being used by people in all walks of life: shoppers, clerks, technicians, engineers, students and others. In fact, in 1976 one of every ten Americans owned a hand-held calculator (21).

At the college level students own hand-held calculators and are using them, especially in the mathematically oriented courses. In an informal survey conducted by the author of this study in the fall of 1976, electronics teachers at one technical institute indicated that 98 percent of their students had hand-held calculators by the time they reached their second semester. Many students in mathematics classes at this institution also have hand-held calculators; however, no concerted effort has been made to integrate the use of the calculator into the curriculum.

Nature of the Problem

The apparent proliferating use of hand-held calculators by students in the classroom has led educators to become

concerned as to whether the use of these instruments provides an educational benefit. Many feel the hand-held calculator can be used to enhance mathematics instruction. It has been suggested that the hand-held calculator can be used to stimulate positive attitudes resulting in improved achievement. There is also some agreement that the availability of the hand-held calculator can encourage the use of more realistic applications problems and thus may lead to improved student motivation.

Those who oppose student use of hand-held calculators argue that students will not learn or remember basic skills and will never understand the procedure involved in certain mathematical concepts if they are allowed to use a hand-held calculator.

The research on most of these issues raised by educators is limited, and the dearth of evidence, either pro or con, on the educational benefits of the hand-held calculator contributes to the quandary on the part of teachers as to whether or not students should be allowed to use hand-held calculators.

Most surveys and articles on the use of the hand-held calculator have reflected teachers' opinions and biases. However, their use should not be justified in this manner, but rather on a basis of whether they promote desirable changes.

There are very few reports of research on the effect of hand-held calculators on either attitude or achievement and

most of the existing research has been conducted at the elementary or junior high level. Therefore, a need for a study of the effect of hand-held calculators on attitude and achievement at the college level seems to be indicated.

The problem which this study addressed was the lack of empirical data regarding the effect of the use of the hand-held calculator on students' attitude toward mathematics and achievement.

The Purpose

The purpose of this study was to answer three questions:

1. Will the use of a hand-held calculator in a college algebra class produce a difference in algebraic achievement?

2. Will there be any difference in students' attitudes toward mathematics between the students who use a hand-held calculator and those who do not?

3. Will there be a significant correlation between students' attitudes toward mathematics and algebraic achievement?

Hypotheses

The hypotheses tested were:

1. There is no significant difference in algebraic achievement between the experimental groups that use hand-held calculators and the control groups that do not.

2. There is no significant difference in students' attitudes toward mathematics between the experimental groups that use hand-held calculators and the control groups that do not.

3. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement. To test this hypothesis four sub-hypotheses were tested. These were:

   a. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on pretest scores of the control groups.

   b. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on pretest scores of the experimental groups.

   c. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on gain scores of the control groups.

   d. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on gain scores of the experimental groups.

Definition of Terms

In order that the terms and concepts used in this study

convey the same meaning to everyone, certain terms need

clarification and are defined as follows:

Attitude

An attitude is the tendency of an individual to respond

positively or negatively to some stimuli, object, individual,

or situation, past or present.

Motivation

To provide an incentive or stimuli that encourages an indi-

vidual to take a desired action.

Hand-held Calculator

A hand-held calculator is a fully portable, battery oper-

ated, electronic calculating machine, which may have several

functions but will have at least the four basic arithmetic

functions.

Corvus 411 Calculator

A four-function hand-held calculator with algebraic entry,

the Corvus 411 has a square root key, a reciprocal key, one

addressable memory cell, and the scientific notation feature.

College Algebra

College algebra is the collection of algebraic concepts

which are prerequisite to the calculus. In this study the

core consisted of: 1) introductory concepts, 2) functions

and their graphs, 3) equations and their solutions, and

4) other topics which were included at the discretion of

the instructor.

Algebraic Achievement

The Cooperative Algebra 1 Test was used in this study to

measure algebraic achievement. Form A was administered as the pretest and form B as the posttest.

Students' Attitudes Toward Mathematics

The Rabinowitz Mathematics Attitude Scale was the instrument used to measure students' attitudes toward mathematics in this study. The scale measures several dimensions of mathematics attitudes: having self-confidence in one's mathematical ability, envisioning mathematics as understandable, acknowledging the applicability of mathematics and enjoying mathematics and not perceiving it as uninteresting.

Gain Score

The gain score was the difference between the pretest and posttest scores. Gain scores were computed for each student on both attitude and achievement as measured by the Rabinowitz Mathematics Attitude Scale and the Cooperative Algebra 1 Test respectively.

CHAPTER II

LITERATURE REVIEW

Attitude and Achievement

The purpose of this chapter is to report a review of
selected literature relative to students' attitude toward
mathematics and to the use of the calculator in the class-
room.

Attitudes and motivations are key concepts in current
learning theories. Mager (23) stated that students' posi-
tive attitudes maximize the possibility that they will will-
ingly learn more and remember longer. This same theme,
effective learning results from an instructional situation
that produces positive attitudes, has been repeated by sev-
eral learning theorists. McKeachie (24) discussed the re-
lationship between attitude and student learning, stating
that:

> Students usually learn what they want to learn; but
> they often have great difficulty learning material
> which does not interest them (p. 1119).

It should be noted that attitude is a term not general-
ly defined, but described by Aiken (2) as:

> A learned predisposition or tendency on the part of
> an individual to respond positively or negatively
> to some object, situation, concept, or another per-
> son (p. 551).

Cattell (6) defined attitude as an interest in a course of action. Mager (23) described attitude as a general tendency of a person to respond in a certain way.

There are several dimensions of attitude as reflected by the types of questions which are included in mathematics attitude scales. Rabinowitz, in personal correspondence (Appendix D), indicated that he patterned his attitude scale after the concepts of Crosby and Freeman who stressed: 1) having self-confidence in one's mathematical ability, 2) envisioning mathematics as understandable, 3) acknowledging the applicability of mathematics, and 4) enjoying mathematics and not perceiving it as uninteresting. Neale (27) said Husen's study contained three measures of attitude: mathematics as a process, difficulty of learning, and its utility. Aiken (3) reported that three of these same constructs of mathematical attitude, value of mathematics in society, self-concept in mathematics, and enjoyment of mathematics, were included in Sandman's 48-item inventory.

Mathematics seems to be a subject to which many students exhibit strong negative attitudes. Poffenberger and Norton (28) reported that of 390 freshmen university students only 25 percent liked mathematics while 24 percent had a strong dislike for mathematics. They also found that the students' perception of parental mathematics attitudes was the biggest factor in their mathematics attitude. Furthermore, they reported that mathematics attitudes are cumulative and get progressively worse.

Dutton (9) in his study of prospective elementary teachers found that attitudes toward mathematics were developed during the period from the 3rd to 6th grades. He also reported that the reason for liking mathematics that was listed by the most students was its practicality and applicability.

Using a Likert type math attitude scale in their study, Aiken and Dreger (4) determined that the scores on the math attitude scale could be used to predict the gain score on the Cooperative Mathematics Pretest for College Students. In the same study they found a positive relationship between math attitudes and numerical ability. Their research indicated no relationship between students' math attitudes and parental encouragement or parental math attitudes. Therefore, they concluded that attitudes are apparently related to intellective factors and achievement.

In a later study Aiken (1) found that attitudes are related to general personality variables, in that women who are more socially and intellectually mature, more self-controlled, and more theoretical value oriented have a better attitude toward mathematics.

Neale (27) evaluated a number of studies on attitudes and mathematics in an effort to determine if students develop an increasingly unfavorable attitude toward mathematics as they go through school, and to determine what part attitudes play in motivating students to learn mathematics. Among those studies reported by Neale (27) was a longitudinal

study by Anttonen in 1967 that indicated a correlation be-
tween attitudes and achievements that ranged from 0.20 to
0.40. However, he stated that findings by Anttonen, Ryan,
Husen and others at the elementary and secondary levels in-
dicated that there was little positive correlation between
mathematical achievement and attitude. He also found that
students' attitude toward mathematics seemed to become more
negative as they progress through school (27). Cattell and
Butcher (6) indicated that the two factors producing the
greatest positive relationship between mathematical achieve-
ment and attitude were submissiveness (+0.50) and superego
(+0.44).

These studies were mostly short term, a semester or
less, and were conducted primarily at the elementary and
junior high school levels. The results in some instances
seem to be contradictory to what has been generally postu-
lated about attitudes and achievement.

In an effort to clear up this confusing picture, Aiken
reviewed the research conducted in the decade of the 1960's.
Aiken (2) discussed the techniques of the research in the
studies as well as the findings.

One of the techniques used to measure attitude was the
observational method. In his review, Aiken (2) stated that
conflicting reports about the effectiveness of the observa-
tional method exist in studies by Brown and Abell who found
that teachers' observations were inadequate in evaluating
their students' attitudes, whereas Ellingson found a positive

correlation between the teachers' rating and their students' inventoried attitudes.

Attitudes appear to vary depending on the age group of the population being tested. Aiken (2) found that research supported the conclusion that attitudes are formed as early as the 3rd grade and that these attitudes are generally positive. Furthermore, the correlations of attitude and achievement during this period are not large, but in some instances are statistically significant. He also reported that one problem at the elementary level is that of readability and interpretation of the test instrument (2).

At the college level, Harrington, in a study as reported by Aiken (2), found no significant relationship between attitude and achievement; however, as previously mentioned, Dreger and Aiken (4) found more significant correlations between the two variables.

Since the research findings indicated that "intrinsic interest" had very little effect on mathematical achievement, then what does? This is a difficult question to answer. Neale (27) said,

> Unfortunately, empirical knowledge about this matter is difficult to find. Mostly what exists is a large body of literature in which opinions about school motivation are recorded (p. 637).

Calculators

Motivation and Achievement

In recent years many articles have been published which

concern the question of whether or not the calculator can be used as a teaching tool to promote understanding and motivation by challenging the student to learn mathematical skills. The authors of many of these articles have implied that the calculator can be used to instill motivation (7, 10, 12, 16, 18). Johnsonbaugh (21) and Etlinger (12) both gave a number of examples in which the calculator can be used as a motivating device.

The limitations of the calculator very often provide its value (12, 17, 36). If the calculator does not have a change of sign key, the student must understand that subtraction may be performed by adding the additive inverse of the subtrahend (36). Also, students must comprehend the hierarchy of operations to obtain the correct answer to a problem such as $3 + 4 \times 5$, because most machines perform operations as they are entered (36).

Some of the justifications for using calculators listed by the NCTM Instructional Affairs Committee (26) are:

1. promoting student independence in problem solving,

2. solving impractical and laborious problems,

3. saving time in difficult computations.

"Real world" problems often are not computationally convenient, and occasionally the techniques, when performed by hand, would require an unrealistic amount of time. Gibb (16) suggested that one possible curriculum change indicated by using the calculator as a learning device would be placing greater emphasis on problem solving, especially real

world problems. Another change might be that of teaching iteration methods for solving simultaneous equations (29).

Another important use of the calculator is to encourage creativity and promote imagination (17,26). Van Atta (35) suggested that the calculator should be used to develop intuitive approaches to certain topics, such as logarithms. Pollak (29) also suggested that the calculator might be helpful in teaching the notion of a function.

There are still a number of questions, however, about calculators and their use that educational research needs to address (12, 16). Some of these questions are:

1. What effect will the use of the calculator have on motivation over a long period of time (12),

2. Will mathematical concepts be better understood (12, 16),

3. Will students explore different methods of solving problems (12),

4. What activities are appropriate and at what age (12)?

Research on the Use of Calculators in the Classroom

Research involving the use of the calculator in the classroom is limited, and it has been conducted mostly at the elementary or junior high school level. Furthermore, several of the studies were conducted on students who were low-achievers in mathematics.

One of the earliest studies was conducted by Fehr,
McMeen, and Sobel (13). Results of a two-week study, in the
spring of 1955, indicated no significant difference in com-
putational or reasoning ability between the group using cal-
culating machines and the group not using calculating
machines. This same group of researchers conducted a semes-
ter long study in the fall and winter in 1955-56. In this
study the group who used calculators made a gain in both
computational and reasoning skills over the non-calculator
group. The gain was not statistically significant, however.

Cech (7), in a study of low-achieving ninth graders,
reported the same results: students' paper and pencil compu-
tational skills were not improved when they used the calcu-
lator during the study but were not allowed to use the
calculator on the posttest. He did find that students who
were allowed to use the calculator on the posttest could
compute better than those not using one. This study was a
short-range study, only seven weeks in length, and one of
his conclusions was that significant changes might occur
over a longer period of time.

Gaslin (15) found that the use of the calculator did
not significantly affect performance when development of
computational skills was the goal. He also reported similar
findings in two other studies by Mastbaum and Johnson. In
fact, Gaslin (15) stated that Johnson found that the group
that used the calculators scored significantly lower than
the group not using them.

In a study which involved remedial college mathematics students, Leitzel and Waits (22) reported that the class of students who used calculators performed as well as previous classes who did not use calculators. The authors also reported that they found no textbook which was suitable to use with calculators, so they created supplementary problem sets. In this same study 81 percent of the students who used calculators agreed that the calculator was helpful to them in the class. Only 46 percent of the students in the study reported their attitude toward mathematics improved.

In other studies in which changes in attitude were measured, no significant difference was found between the calculator and non-calculator group (7, 15). Gaslin (15) reported, however, that Johnson found that low and middle ability students who used calculators had more positive attitudes toward mathematics than the non-calculator groups.

Cech (7) suggested that the use of the calculator when used as a teaching device might be effective for other objectives, such as solving meaningful problems, promoting understanding, and illustrating principles of mathematics. This view was also supported by a study conducted by the Editorial Panel (10) of The Mathematics Teacher. In this study 96 percent of the respondents agreed that the calculator could be used to provide more meaningful applications problems.

In a study at the elementary level, Schnur and Lang (31) reported that the experimental group, who used calculators,

gained significantly at the 0.001 level in their mathematical computational ability.

A project organized by the Bureau of Mathematics Education, New York State Education Department, was conducted during the 1973-74 school year at two sixth grade classes in New York (34). Some of the findings of this project, as reported by Sullivan (34), were:

1. The students were interested in using the calculators and thought using them was fun,

2. The calculators seemed to motivate students to explore advanced topics,

3. Students used the calculators to solve verbal problems and some students created their own verbal problems.

The Instructional Affairs Committee of the National Council of Teachers of Mathematics (26) adopted the following position statement:

> With the decrease in cost of the mini-calculator, its accessibility to students at all levels is increasing rapidly. Mathematics teachers should recognize the potential contribution of this calculator as a valuable instructional aid. In the classroom, the mini-calculator should be used in imaginative ways to reinforce learning and to motivate the learner as he becomes proficient in mathematics (p. 72).

Summary

Neale (27) reported that the studies he reviewed supported the conclusions that 1) students' attitudes toward mathematics became progressively worse as they proceeded

through school, and 2) that the attitudes of students toward mathematics have only a slight influence on their mathematical achievement.

There were two articles by Aiken in which he reviewed the research on attitudes; in one he reviewed the research during the 1960's and in the other the research from 1970 to 1975. Aiken (2), in his review of the research in the 1960's, indicated that these studies showed a low to moderate correlation between attitude and achievement. In his second review, he reported that at all levels there was a low but statistically significant correlation when attitudes were used to predict achievement in mathematics (3).

A large number of studies describing research on various aspects of attitude was available. Aiken reviewed 118 articles in "Update on Attitudes and Other Affective Variables in Learning Mathematics." Only three articles dealing with the effect of calculators on mathematics attitudes were reported by Aiken. The results of all three of these studies were that there was not a significant difference in change in attitude between the groups who used calculators and those who did not (3).

The apparent interest of mathematics educators in the use of the calculator in the classroom is demonstrated by the proliferation of articles about them written in the last several years. The topics in these articles can be broadly categorized into two areas, the applications of the calculator in the current curriculum and the impact of the

calculator on future curriculum development. That one jour-
nal, The Arithmetic Teacher, devoted one issue to the mini-
calculator is also indicative of this interest in calculators.

Most of the recent articles, however, were not reports
of statistical research but were generally the author's ob-
servations or biases about using calculators. The research
that has been reported was mostly at the elementary or
junior high level.

CHAPTER III

METHODOLOGY

Introduction

The purpose of this chapter is to describe the
research design, relate how the subjects were chosen, and
discuss the analysis of data.

The Experimental Design

The Nonequivalent Control Group Design, as described
by Campbell and Stanley (5) was the design used for this
study. It involves control and experimental groups which
are pretested and posttested, but which do not have pre-
experimental sampling equivalence. In this design, subjects
are not randomly assigned to groups, but are naturally con-
stituted groups such as classrooms. The more closely
matched the groups are, as demonstrated by pretest scores,
the better the factors influencing internal validity are
controlled. The design controls the main sources of inter-
nal validity except for maturation and intrasession history.
It should be noted, however, that in this study one source
of internal validity could not be completely controlled
because the experimental group and control group were not

run simultaneously; therefore, the history was different
for the two groups. In an effort to counterbalance this
effect, two control groups and two experimental groups were
offered both in the fall and the spring semesters, see
Table I.

Selection of the Subjects

The subjects for this study were students enrolled in
selected college algebra classes in four two-year colleges
in Oklahoma during 1975 and 1976. The four institutions
were Claremore Junior College, South Oklahoma City Junior
College, Seminole Junior College, and Oklahoma State Univer-
sity Technical Institute, Oklahoma City. A brief descrip-
tion of each institution is given in Appendix E.

These institutions were selected because the Mathe-
matics Department Chairman at each institution agreed to
support the study and to assign one instructor to teach
both a control and experimental group using the same
course outline and textbook for both groups.

Table I lists the institution, the teacher, the semes-
ter, the initial number of students, and the number of
students included in the analysis of the data for each of
the groups.

Description of Control Groups

There was one control group at each of the four
selected institutions. Students in each control group

TABLE I

DESCRIPTION OF RESEARCH GROUPS

| Group | Semester | Institution | Instructor | N | Number of Students Included in Analysis of Data | |
					Achievement	Attitude
1. Control	Spring 75	Claremore Junior College	Dr. Jerry Smith	26	20	20
1. Experimental	Fall 75			20	20	20
2. Control	Spring 75	South Oklahoma City Junior College	Jack Cain	23	11	11
2. Experimental	Fall 75			28	20	19
3. Control	Fall 75	Seminole Junior College	Clarence Cowan	29	19	18
3. Experimental	Spring 76			23	9	9
4. Control	Fall 75	Oklahoma State University Technical Institute	Annette Cooper	24	9	9
4. Experimental	Spring 76			24	10	10

*Scores must be available for both pretest and posttest for either attitude or achievement to be included in the analysis of the data. Foreign students were eliminated from the study.

were those who were regularly enrolled in the class to be taught by the instructor assigned to participate in the study. The control group at each institution used the textbook and course outline normally used by college algebra classes at that institution. Each teacher used the teaching methodology which he normally used for a college algebra class. These groups were:

Control Group 1. Claremore Junior College

Control Group 2. South Oklahoma City Junior College

Control Group 3. Seminole Junior College

Control Group 4. Oklahoma State University Technical Institute, Oklahoma City

Description of Experimental Groups

At each of the four institutions there was an experimental group which was taught by the same instructor who taught the control group at that institution. The same textbook and course outline which was used for the control group at a particular institution was also used for the corresponding experimental group. Each teacher's teaching methodology was the same for the experimental group as it was for the respective control group. In addition handheld calculators were made available to students in the experimental groups and they were encouraged to use them. These groups were:

Experimental Group 1. Claremore Junior College

Experimental Group 2. South Oklahoma City Junior College

Experimental Group 3. Seminole Junior College

Experimental Group 4. Oklahoma State University Tech-
nical Institute, Oklahoma City

Experimental Treatment

At each institution which participated in the study,
the control group and experimental group used that particu-
lar institution's course outline and adopted textbook. The
teacher who taught both groups was the teacher assigned to
participate in the study at that institution.

The students in the experimental group were given the
opportunity to borrow a Corvus 411 calculator. If a stu-
dent had his own hand-held calculator, however, he was
allowed to use it. It was relatively easy to learn to
operate the Corvus 411 calculator, and it was assumed that
a student who had his own hand-held calculator could oper-
ate it. Students received instruction in how to use the
hand-held calculator and were given approximately a week
to use the hand-held calculator before the pretest was
administered. During the rest of the semester the stu-
dents were encouraged to use the hand-held calculator and
were given appropriate algorithms or were encouraged to
develop them when necessary. The experimental groups were
allowed to use the hand-held calculators on all tests given
during the semester including the pretest and posttest while
the control groups were not allowed to use them. Students
were informed that their grade would not be affected by
their performance on the pretest and posttest.

Time Schedule

Control groups 1 and 2 participated in the study during the spring of 1975 with experimental groups 1 and 2 participating during the fall of 1975. Control groups 3 and 4 participated during the fall of 1975 with experimental groups 3 and 4 participating during the spring of 1976. This time schedule was chosen for the following reasons:

1. The control group was scheduled first to prevent adverse feelings resulting from one group of students being allowed to use hand-held calculators and the following group being denied this "privilege";

2. Not all of the colleges had two college algebra classes being offered in the same semester causing the offering of a control group one semester followed by the experimental group the next;

3. Due to the prerequisite structure, fall semester college algebra students may have differing abilities than the spring semester students. Thus control groups were run in both spring and fall semesters;

4. Only one-half as many calculators were needed as two groups used the calculators in the fall and two groups used the same calculators in the spring.

Data Collection

The Rabinowitz Mathematics Attitude Scale was used to measure students' attitude toward mathematics. It was administered as a pretest to each group near the end of the second week of the semester. During the last week of the semester, prior to final examination, this same scale was given as a posttest to each group.

The Cooperative Algebra Test, forms A and B, were used to measure algebraic achievement. Form A was utilized as the pretest while form B was administered as the post-test. Both pretests and posttests of the Cooperative Algebra Test were administered on the same time schedule as the Rabinowitz Mathematics Attitude Scale.

At the end of the study an informal interview was conducted with each teacher who participated in the study to determine his reaction to the use of the hand-held calculator by students in the study.

The Test Instruments

The Rabinowitz Mathematics Attitude Scale (Appendix A) was used in this study to measure students' attitudes toward mathematics.

Each subject responded to 50 statements about mathematics by marking a letter corresponding to his answer. It was an agree/disagree type scale. The scoring key, as provided by Dr. Rabinowitz, is shown in Appendix A.

The student's score was the number of responses which were in agreement with the answers in the key.

The Rabinowitz Mathematics Attitude Scale was originally designed to be used with 9th grade mathematics students; however, it has been administered to students from the elementary to the graduate level with reliability ranging from 0.85 to 0.905 (32). In personal correspondence with Dr. Rabinowitz (Appendix D), he indicated that the test was constructed to measure certain attributes of attitude and that those items on which the experts did not agree were discarded.

Furthermore, a questionnaire regarding the validity of the Rabinowitz Mathematics Attitude Scale was administered to the members of the Oklahoma Junior College Mathematics Association, a group of mathematics teachers in two-year colleges in the state of Oklahoma. The results of this survey was that in the opinion of the members of the Oklahoma Junior College Mathematics Association the Rabinowitz Mathematics Attitude Scale would provide a valid measure of their students' attitude toward mathematics.

The Cooperative Algebra Test was used to measure algebraic achievement. It is a 40 item, 40 minute, timed test. The two alternate forms, A and B, have KR reliability ranging from 0.84 to 0.86 (11).

Analysis of Data

The data from each pair of control and experimental groups (Appendix B) was analyzed separately. Foreign students' scores were omitted from the analysis to eliminate the possibility of reading problems that might affect the data. This technique was employed by Fehr, McMeen, and Sobel (13) when they eliminated scores of psychologically disturbed children in their study.

The scores for each individual were paired as suggested by Steel and Torrie (33). Gain scores, the difference between the paired scores, were computed; if a student did not take both the pretest and posttest, his gain scores could not be calculated. If gain scores were available for either attitude or achievement, that score was included in the computation of the data. Cech (7) used a technique similar to this in his study in which he utilized the difference in pretest and posttest scores as the data for computing the t statistic, which was tested for significance at the 0.05 level.

The Student t test statistic was used to test the following hypotheses:

1. There is no significant difference in algebraic achievement between the experimental groups that use the hand-held calculators and the control groups that do not.

2. There is no significant difference in students'
   attitudes toward mathematics between the experi-
   mental groups that use hand-held calculators and
   the control groups that do not.

According to Popham (30) the t test is employed to
determine how large a difference in the means is necessary
to be considered significant. The underlying assumptions
for the t test are that the sample has been drawn from a
normally distributed population and that the data is at
least ordinal in nature. Popham (30) stated that devia-
tions can be made from the assumptions without affecting
the interpretation of the t value. For example, he sug-
gested that, since it is usually not practical in educa-
tional studies to use random sample techniques, careful
consideration be given to insure that the sample drawn
is not biased. In an effort to minimize any bias which
might result from a difference in the abilities between
spring and fall college algebra classes due to the pre-
requisite structure in the curriculum of the institutions,
two control groups and two experimental groups were con-
ducted each semester.

The Pearson product-moment correlation was used to
test hypothesis 3 and the four sub-hypotheses:

There is no significant correlation between students'
attitudes toward mathematics and mathematical
achievement.

a. There is no significant correlation between

students' attitudes toward mathematics and
mathematical achievement on pretest scores of
the control groups.

b. There is no significant correlation between
students' attitudes toward mathematics and
mathematical achievement on pretest scores of
the experimental groups.

c. There is no significant correlation between stu-
dents' attitudes toward mathematics and mathe-
matical achievement on gain scores of the control
groups.

d. There is no significant correlation between stu-
dents' attitudes toward mathematics and mathe-
matical achievement on gain scores of the
experimental groups.

The underlying assumptions for the product-moment
correlation are that of homoscedasticity and linearity.
Popham (30) stated that if the data was approximately linear
then the assumption of homoscedasticity was also generally
satisfied.

The product-moment r was calculated using the paired
attitude and achievement gain scores of each student for
both control and experimental groups. It was also computed
on the paired scores for attitude and achievement obtained
on the pretest only.

The tests were all hand-scored with all table entries
double checked, and the test statistics for the Student t

and the Pearson product-moment r were calculated by computer.

The t and r test statistics were tested for significance at the 0.05 level since this is the level most commonly used by applied statisticians (19).

Assumptions

The first assumption is that the experimental and control groups were normally distributed. Even though the students in the groups were not randomly selected, the students had no previous knowledge of the experiment before they enrolled. Secondly the data is assumed to be at least ordinal since test scores were the number of correct responses to both the Cooperative Algebra Test and the Rabinowitz Mathematics Attitude Scale.

The t model used depends on several factors: 1) the homogeneity of variances, 2) the sample sizes, and 3) the presence of correlation between the data. It was assumed that there was no correlation of data since the data represented mean gain scores of the control and experimental groups. Since there was no pre-experimental data to determine equivalence of groups, the F test was used to test for homogeneity of variance at the 0.10 level.

Furthermore, it was assumed that the mathematics achievement test did not measure competence in manipulating the hand-held calculator. It was assumed that students who used their own hand-held calculators in the study were

skilled in the use of their machines, and the students who used the Corvus 411's in the study learned how to use them before the pretest was administered. It was also assumed that the students in the experimental groups actually used the hand-held calculators.

CHAPTER IV

RESULTS

Introduction

The purpose of this chapter is to report the data collected, to compute the test statistics discussed in Chapter III, to determine if they are statistically significant, and to dispose of the hypotheses of this study at the 0.05 level. The data for each control group and corresponding experimental group was treated separately. Raw scores are located in Appendix B. If a student did not complete at least the pretest and posttest for one of the parts, attitude or achievement, the results were listed as incomplete data and were not used in the analysis of the data. Some of the reasons for students not completing all four tests were:

1. not in attendance the day the test was given,

2. not completing the entire attitude scale (it was not a timed test),

3. withdrawing before the end of the semester.

Furthermore, all foreign students were eliminated from the study since their scores may have reflected gains in reading ability as well as changes the tests were designed to measure.

Differences in Achievement

The Student t statistic was used to test the first
hypothesis:

There is no significant difference in algebraic
achievement between the experimental groups that
use hand-held calculators and the control groups
that do not. .

The number of students, the mean and standard deviation
of the pretest scores, the mean and variance of the gain
scores, the F ratio, and the appropriate t statistic for
each group are shown in Table II. The mean and standard
deviation of the pretest scores were included in the table
as an indication of the equivalence of each control group
and the corresponding experimental group.

Scores on the Cooperative Algebra Test, a forty item
test, provided the raw data (Appendix B) used in the t
test. Gain scores, the difference in pretest and posttest
scores, were averaged for both control and experimental
groups.

The variance of the gain scores of the control and
experimental groups was then computed and the F ratio,
largest variance divided by the smallest variance, was
calculated. The F ratio was then tested at the 0.10 level
with n-1 degrees of freedom for each variable. If the
calculated F value was less than the table value, the
variances were assumed to be homogeneous. The calculated

TABLE II

DIFFERENCE IN MATHEMATICAL ACHIEVEMENT

Group	Number	Mean Pretest Scores	Std. Dev. Pretest Scores	Mean Gain Scores	Variance Gain Scores	F	$F_{.10}$	t	$t_{.05}$
1. Control (Spring 1975)	20	25.55	6.88	5.15	21.87				
1. Experimental (Fall 1975)	20	27.60	6.49	4.60	21.305	$1.006 < 2.53$, F(19,19)		$0.255 < 2.025$, t(38df)	
2. Control (Spring 1975)	11	31.82	5.44	.36	5.655				
2. Experimental (Fall 1975)	20	30.03	5.64	-.30	34.642	$6.126 > 3.34$, F(19,10)		$0.355 < 2.13$*	
3. Control (Fall 1975)	19	26.42	4.62	3.74	11.760				
3. Experimental (Spring 1976)	9	22.89	4.73	1.89	14.611	$1.242 < 3.01$, F(8,18)		$0.931 < 2.056$, t(26df)	
4. Control (Fall 1975)	9	23.89	6.47	1.33	31.75				
4. Experimental (Spring 1976)	10	26.90	4.63	0.70	21.122	$1.503 < 4.10$, F(8,9)		$0.264 < 2.110$. t(17df)	

*Cochran Cox formula

F ratio and the table value were recorded in Table II.

The formula used to compute the t statistic depended on whether the variances were homogeneous, as determined by the F test. If the variances were homogeneous, the pooled variance formula was used; otherwise the separate variance formula was used. Both formulas are located in Appendix C.

According to Steel and Torrie (33), when the t statistic is used to test the hypothesis that there is no difference in population means, $\mu_1 = \mu_2$ as opposed to $\mu_1 \neq \mu_2$, it is immaterial as to whether $\overline{x}_1 - \overline{x}_2$ or $\overline{x}_2 - \overline{x}_1$ is considered. Since this is the case for the first hypothesis, the unsigned t value was reported in Table II and a two-tailed table value, with $n_1 + n_2 - 2$ degrees of freedom, was used as the test criterion at the 0.05 level. The calculated t statistic and the table value are listed.

The mean gain score of the control group was greater than the mean gain score of the experimental group for each of the four corresponding pairs of groups. For control and experimental groups 1, 3, and 4, the calculated F ratio was less than the table value with the appropriate degrees of freedom at the 0.10 level. Therefore, the variances were assumed to be homogeneous and the t statistic was computed using the pooled variance formula (Appendix C). The t statistics computed for control and experimental groups 1, 3, and 4 were all less than the respective table values with $n_1 + n_2 - 2$ degrees of freedom at the 0.05 level.

The F ratio, 6.126, calculated using the second control and experimental group, is greater than 3.34, the table value. Therefore, the variances were not assumed to be homogeneous and the separate variance formula (Appendix C) was used to compute the t statistic.

The approximate t value necessary for significance at the 0.05 level was found by

$$t_{.05} = \frac{\frac{s_1^2}{n_1} t_1 + \frac{s_2^2}{n_2} t_2}{s_1^2/n_1 + s_2^2/n_2} \quad (8)$$

None of the four t values were statistically significant; therefore, the hypothesis was not rejected.

Difference in Attitude

The Student t statistic was also used to test the second hypothesis:

There is no significant difference in students' attitudes toward mathematics between the experimental groups that use hand-held calculators and the control groups that do not.

Table III is identical in construction to Table II, with all F and t values calculated as they were for the first hypothesis. Raw scores on the Rabinowitz Mathematics Attitude Scale, a fifty item test, were used to compute the data exhibited in Table III.

TABLE III

DIFFERENCE IN MATHEMATICAL ATTITUDE

Group	Number	Mean Pretest Scores	Std. Dev. Pretest Scores	Mean Gain Scores	Variance Gain Scores	F	$F_{.10}$	t	$t_{.05}$
1. Control (Spring 1975)	20	35.30	8.87	0.45	17.208				
1. Experimental (Fall 1975)	20	37.20	5.29	-1.75	34.366	1.997 < 2.53, F(19,19)		0.862 < 2.025, t(38df)	
2. Control (Spring 1975)	11	40.90	4.32	.64	10.255				
2. Experimental (Fall 1975)	19	36.47	5.76	.68	35.117	3.245 < 3.58, F(18,10)		0.024 < 2.048, t(28df)	
3. Control (Fall 1975)	18	35.17	7.45	-0.67	60.471				
3. Experimental (Spring 1976)	9	30.78	8.24	-2.22	29.694	2.036 < 4.06, F(17,8)		0.525 < 2.060, t(25df)	
4. Control (Fall 1975)	9	29.78	8.44	-1.56	46.528				
4. Experimental (Spring 1976)	10	30.50	8.20	-2.80	21.289	2.186 < 4.10, F(8,9)		0.433 < 2.120, t(17df)	

In Table III, the mean gain score for control groups
1, 3 and 4 was greater than the mean gain score of the cor-
responding experimental groups. The mean gain score of
experimental group 2 was greater than the mean gain score
of control group 2; however, the difference in the mean
gain scores was only 0.04.

All four of the F ratios, used to test for homogeneity
of variances, were less than the critical value at the 0.10
level; therefore, the pooled variance formula (Appendix C)
was used to calculate the t statistic in each instance.
None of the t values were critical at the 0.05 level. The
hypothesis was, therefore, not rejected.

<div align="center">

Correlation Between Attitude

and Achievement

</div>

Hypothesis 3, there is no significant correlation
between students' attitudes toward mathematics and mathe-
matical achievement, was tested by using four sub-
hypotheses. The four sub-hypotheses are:

a. There is no significant correlation between stu-
dents' attitudes toward mathematics and mathemati-
cal achievement on pretest scores of the control
groups.

b. There is no significant correlation between stu-
dents' attitudes toward mathematics and mathemati-
cal achievement on pretest scores on the experi-
mental groups.

c. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on gain scores of the control groups.

d. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on gain scores of the experimental groups.

Tables IV, V, VI, and VII correspond to sub-hypotheses a, b, c, and d respectively. The tables contain the calculated Pearson product-moment correlation coefficient r. The formula used to calculate r is given in Appendix C. The r values in Tables IV and V were calculated using paired attitude and achievement pretest scores. Paired gain scores were used to compute the r values in Tables VI and VII. The raw scores are given in Appendix B.

The tables are identical in construction. Each table contains the sample sizes, the r value, the corresponding z value, the standard error ($\sigma_z = \frac{1}{\sqrt{N-3}}$), and the test value z/σ_z.

The r's were transformed to Fisher z values to produce a statistic which is approximately normal using the formula:

$$ z = \tfrac{1}{2}\ln(\frac{1 + r}{1 - r}) \quad (14). $$

In order for the test value z/σ_z to be significant at the 0.05 level using a two-tailed test, $z/\sigma_z > 1.96$ or $z/\sigma_z < -1.96$.

TABLE IV

PRETEST SCORES--CONTROL GROUP

Group	n	r	z	$z = \dfrac{1}{\sqrt{N-3}}$	$\dfrac{z}{\sigma_z}$
1	20	0.508	.560	.243	2.31*
2	11	0.557	.628	.354	1.78
3	18	0.479	.522	.258	2.02*
4	9	-0.042	-.042	.408	-.10

TABLE V

PRETEST SCORES--EXPERIMENTAL GROUP

Group	n	r	z	$z = \dfrac{1}{\sqrt{N-3}}$	$\dfrac{z}{\sigma_z}$
1	20	0.523	.243	.243	2.44*
2	19	0.163	.408	.408	0.40
3	8	0.500	.447	.447	1.23
4	10	0.119	.378	.378	0.32

*Significant at the 0.05 level

TABLE VI

GAIN SCORES--CONTROL GROUP

Group	n	r	z	$z = \frac{1}{\sqrt{N-3}}$	$\frac{z}{\sigma_z}$
1	20	-0.334	- .347	.243	-1.48
2	11	-0.101	-0.101	.354	- .29
3	18	0.238	0.243	.258	.94
4	9	-0.278	-0.286	.408	- .70

TABLE VII

GAIN SCORES--EXPERIMENTAL GROUP

Group	n	r	z	$z = \frac{1}{\sqrt{N-3}}$	$\frac{z}{\sigma_z}$
1	20	.318	.329	.243	1.36
2	19	-0.015	-0.015	.250	- .06
3	8	0.806	1.115	.447	2.49*
4	10	-0.159	-0.160	.378	- .42

*Significant at the 0.05 level

In Table IV two the four z/σ_z values, those for groups 1 and 3, were statistically significant at the 0.05 level. In Table V only one of the four z/σ_z values was statistically significant, the value for group 1. None of the z/σ_z values were statistically significant in Table VI, and only one was statistically significant in Table VII, the z/σ_z value for group 3. There was not enough evidence to reject any of the four sub-hypotheses.

Teacher Comments

At the end of the study each teacher was interviewed in order to ascertain his impressions about his own and his students' attitudes toward using the calculator. Each teacher was also asked to name some topics where the calculator was found to be a useful aid.

Teacher, Claremore Junior College

1. The students were more willing to work with approximation techniques and iterative procedures.
2. More time was spent on the topic of approximation of roots of polynomial expressions.
3. Numerous students commented that the practice in calculator usage helped them in other classes.
4. Apparently many students acquire calculators but do not learn to use them effectively.
5. Our students seldom get excited about anything educationally, and the calculator did not change their basic attitude.

6. I did perceive less reluctance to topics which are tedious, computationally.

7. As an instructor, it is my feeling that the calculator will motivate tremendous change in mathematics instruction.

8. What is the instructor to do? Should he drill, drill, drill, thereby producing expert human computers? Or, should he exploit the calculator by teaching its effective usage and begin exploration of the real uses of mathematical processes and ideas? In brief, I am for using the calculator to the fullest advantage.

Teacher, South Oklahoma City Junior College

1. The calculator provided the greatest help in approximating roots of polynomials.

2. The use of the calculator enabled us to concentrate on the techniques and not the arithmetic.

3. We used the calculator to do the addition and subtraction of logarithms.

4. I was concerned that the students did not take the pretest and posttest seriously enough since they did not affect their grades.

5. The students found the calculator helpful in some of the optional units such as linear programming.

6. I do not see any disadvantages if the student uses a calculator.

Teacher, Seminole Junior College

1. Most of the basic operations in the algebra class were verified by the calculator, and I considered this of great value, because someone other than the instructor was talking.

2. Our book was not designed for use with a calculator and for this reason the students preferred to evaluate the problems by pencil. I noticed the majority of the class came to class without the instrument. As far as I could tell no one used it at testing time or outside of class.

Teacher, Oklahoma State University Technical Institute

1. At the beginning of the semester many of my students had calculators of their own, but most of them could not use them very efficiently.

2. I showed them certain iterative techniques and algorithms which they used frequently.

3. My students used the calculators primarily to evaluate functions and to approximate roots.

4. The posttest was given too close to the end of the semester. The students were tired of school and of tests. Furthermore they still had finals to take. No one spent the full forty minutes allowed on the Comprehensive Algebra Test.

5. The students used the calculators on tests but started using them in class only after I brought mine to class to use.

6. Of the seventy to eighty calculators loaned to
   students during the study only two were not
   returned.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Summary

With the apparent proliferating use of the hand-held
calculator by students in the classroom, educators have
become concerned as to whether the use of this instrument
provides an educational benefit. Some educators have
suggested that the hand-held calculator could be used to
stimulate positive attitudes toward mathematics and improve
mathematical achievement.

This study addressed the problem regarding the lack of
empirical data concerning the effect of the use of the
hand-held calculator on students' attitudes toward mathe-
matics and mathematical achievement.

The purpose of this study was to answer three
questions:

1. Will the use of a hand-held calculator in a
    college algebra class produce a difference in
    algebraic achievement;

2. Will there be any difference in students' atti-
    tudes toward mathematics between the students
    who use a hand-held calculator and those who do
    not;

3. Will there be a significant correlation between students' attitudes toward mathematics and algebraic achievement?

The study was conducted at four selected two-year colleges in Oklahoma. Two control groups were conducted in the spring of 1975 and the corresponding experimental groups in the fall of 1975. The remaining two control and experimental groups participated in the fall of 1975 and the spring of 1976 respectively. Four teachers were used in the study, each taught a control group and a corresponding experimental group. Pretests and posttests for both attitude and achievement were administered to the control and the experimental groups.

Individual gain scores were computed and the Student t test was used to determine if there was a difference in attitude or achievement between the groups which used the calculators and the groups that did not. The Pearson product-moment correlation coefficient was used to determine if there was a relationship between attitude and achievement.

Limitations

There are several conditions which might affect the generalizability of the results of this study. These limitations are listed so the reader may be aware of them.

The study was restricted to college algebra students in four selected two-year colleges in Oklahoma. The

students used in the study were not randomly selected but were selected on the basis of availability and location.

In all of the groups the posttest was given at the end of the semester, therefore the students' attitudes may have been adversely affected by the timing of the posttests.

Students were aware of the study, thus the Hawthorne affect might have influenced the results.

There was no alternate form of the Rabinowitz Mathematics Attitude Scale, therefore taking the pretest may have affected the results of the posttest.

Disposition of Hypotheses

The t test was used to test Hypothesis 1:
There is no significant difference in algebraic achievement between the experimental groups that use hand-held calculators and the control groups that do not.

Gain scores, the difference between pretest and posttest scores, were computed, and the t test was employed to determine if the difference between the mean gain score of each control group and the mean gain score of the corresponding experimental group was significant. The computed t statistic and corresponding table values at the 0.05 level are given on the following page.

1. Claremore Junior College $t=0.255$ $t_{.05}=2.025$

2. South Oklahoma City Junior $t=0.355$ $t_{.05}=2.13$

3. Seminole Junior College $t=0.931$ $t_{.05}=2.056$

4. OSU Technical Institute $t=0.264$ $t_{.05}=2.110$

None of the t values were critical at the 0.05 level. There was no statistically significant difference in algebraic achievement between the groups that used a hand-held calculator and those that did not. Therefore, Hypothesis 1 was not rejected.

The t test was also used to test Hypothesis 2:

There is no significant difference in students' attitudes toward mathematics between the experimental groups that use hand-held calculators and the control groups that do not.

Gain scores, the difference between pretest and posttest scores on the Rabinowitz Mathematics Attitude Scale, were computed, and the t test was used to determine if the difference between the mean gain score of each control group and the mean gain score of the corresponding experimental group was statistically significant. The computed t statistic and corresponding table values at the 0.05 level are given below.

1. Claremore Junior College $t=0.862$ $t_{.05}=2.025$

2. South Oklahoma City Junior $t=0.024$ $t_{.05}=2.048$

3. Seminole Junior College $t=0.525$ $t_{.05}=2.060$

4. OSU Technical Institute $t=0.433$ $t_{.05}=2.120$

None of the t values were critical at the 0.05 level. There was no statistically significant difference in attitude between the groups that used hand-held calculators and those groups that did not. Hypothesis 2 was not rejected.

The Pearson product-moment correlation coefficient was used to test the four sub-hypotheses which were used to test Hypothesis 3. Hypothesis 3 and the four sub-hypotheses are:

There is no significant correlation between students' attitudes toward mathematics and mathematical achievement.

a. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on pretest scores of the control groups.

b. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on pretest scores of the experimental groups.

c. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on gain scores of the control groups.

d. There is no significant correlation between students' attitudes toward mathematics and mathematical achievement on gain scores of the

experimental groups.

The product-moment correlation coefficients were transformed to Fisher z values. The test value z/σ_z was critical at the 0.05 level if $z/\sigma_z > 1.96$ or $z/\sigma_z < -1.96$.

The z/σ_z values for sub-hypothesis a were:

1. Claremore Junior College   2.31
2. South Oklahoma City Junior College   1.78
3. Seminole Junior College   2.02
4. OSU Technical Institute   -0.10

Two of the test values were statistically significant at the 0.05 level, those for Claremore Junior College and Seminole Junior College. There was not enough evidence to reject sub-hypothesis a.

The z/σ_z values for sub-hypothesis b were:

1. Claremore Junior College   2.44
2. South Oklahoma City Junior College   0.40
3. Seminole Junior College   1.23
4. OSU Technical Institute   0.32

Only one of the four z/σ_z values were statistically significant at the 0.05 level, the value for Claremore Junior College. Sub-hypothesis b was not rejected.

The z/σ_z values for sub-hypothesis c were:

1. Claremore Junior College   -1.48
2. South Oklahoma City Junior College   -0.29
3. Seminole Junior College   0.94
4. OSU Technical Institute   -0.70

None of these values were statistically significant at the 0.05 level. Sub-hypothesis c was not rejected.

The z/σ_z values for sub-hypothesis d were:

1. Claremore Junior College   1.36

2. South Oklahoma City Junior College   -0.06

3. Seminole Junior College   2.49

4. OSU Technical Institute   -0.42

The only test value which was statistically significant for this sub-hypothesis was the z/σ_z value for Seminole Junior College. Sub-hypothesis d was, therefore, not rejected.

Since none of the four sub-hypotheses were rejected, Hypothesis 3 was not rejected.

Conclusions

Achievement

Two basic topics permeated the literature on calculators:

1. The effect of the use of the calculator in current mathematics instruction,

2. Curriculum changes which will be indicated by using the calculator as a learning device.

Since students have hand-held calculators and are using them in non-calculator oriented classes, this study was restricted to the first topic, the effect of the use of the calculator in the current curriculum. The hand-held

calculator was used within the existing framework of the class. The same textbook, course outline, and teaching methodologies were used for the experimental groups and the control groups as had been used in previous semesters. All of the textbooks were designed for paper and pencil computations, and many of the problems included in the problem sets were not applications oriented.

The results of this study indicate that when students use the hand-held calculator within the existing curriculum, their mathematical achievement did not improve; however, there was no significant negative effect. It is concluded that the use of the hand-held calculator had no effect on algebraic achievement.

Attitudes

Tests or inventories used to measure students' attitudes toward mathematics often include such concepts as liking or disliking mathematics, feeling mathematics is applicable, believing that one can learn mathematics, and thinking that mathematics has a role in society (27).

Rabinowitz indicated that he considered four concepts when he constructed his scale: 1) having self-confidence in one's mathematical ability, 2) envisioning mathematics as understandable, 3) acknowledging the applicability of mathematics, and 4) enjoying mathematics and not perceiving it as uninteresting. The scale was a measure of the students' composite mathematical attitudes.

The results of this study indicate the use of hand-held calculator did not affect students' attitudes toward mathematics. It is concluded that the use of a hand-held calculator had no affect on students' attitudes toward mathematics.

Attitudes and Achievement

There is a widespread belief that students' attitudes toward mathematics have an affect on students' mathematical achievement (23, 24, 27). Neale (27) found, however, that attitudes toward mathematics have only a slight affect on mathematics achievement.

In this study, of the eight correlation coefficients computed on the gain scores, only one experimental group was statistically significant. This group contained only eight students, however, and Steel and Torrie (33) stated that for small sample sizes, sample r values are variable, since one sample can make a large difference. There were three statistically significant groups when the correlation coefficient r was computed using the pretest raw scores. These groups were control group 1, experimental group 1, and control group 3.

For the majority of the groups tested in this study, there was a low to moderate correlation between attitude and achievement, and in some instances the correlation was statistically significant. However, there is no evidence

to support the conclusion that there is significant corre-
lation between attitude and achievement.

<div align="center">Recommendations</div>

Since neither students' attitudes toward mathematics
nor their mathematical achievement was affected by the use
of a hand-held calculator in this study, it is recommended
that teachers allow students to use hand-held calculators
if it is consistent with their course objectives.

In this study only composite attitudes were considered.
No attempt was made to determine changes in different
dimensions of attitude. It is possible that using the
calculator can affect some dimensions of attitude but not
others. For example, the concept of the applicability of
mathematics might be affected. One teacher indicated that
several of his students stated that the practice in calcu-
lator usage helped them in other classes.

It is also recommended that studies be conducted to
determine the effect of the hand-held calculator when cer-
tain curriculum changes are introduced. The use of the
hand-held calculator in conjunction with the introduction
of more "real world" problems might affect students' atti-
tudes toward the applicability of mathematics, since these
problems are often computationally tedious. One teacher
observed that his students who used the hand-held calculator
were less reluctant to attempt problems which were tedious
computationally. Also one teacher indicated that his

students found the calculator useful for applications in topics such as linear programming.

Perhaps students who have poor mathematical attitudes lack motivation to achieve on mathematical tests unless some incentive is provided. It is recommended that a study be conducted in which the pretest and posttest scores influence the students' final grade.

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APPENDIX A

RABINOWITZ MATHEMATICS ATTITUDE SCALE

RABINOWITZ MATHEMATICS ATTITUDE SCALE

How Do You Feel About Mathematics?

Listed below are 50 statements about mathematics. You will probably agree with some and disagree with others. You can indicate your attitude toward each statement by marking "Agree" or "Disagree" on the separate answer sheet. There are no right or wrong answers.

1. It takes me a long time to catch on to a new topic in mathematics.

2. Very often in mathematics courses, I cannot see a clear relationship between one topic and another.

3. I get a great deal of satisfaction out of solving a problem in math.

4. I can't see how most of the mathematics I have learned thus far will really help me very much in later life.

5. In mathematics you have to be able to remember an awful lot of rules that don't make too much sense.

6. I find mathematics clear.

7. To do well in mathematics, it's more important to think clearly than to have a good memory.

8. Mathematics is such a hard subject that a student usually can't get very much help from another student.

9. When I get an answer to a mathematical problem, I usually can't tell whether it's right or wrong until the teacher gives the correct answer.

10. Unless a mathematics teacher gives many quizzes, most students will soon fall far behind.

11. In mathematics, ideas have a logical relationship to one another.

12. Mathematics is probably the most difficult subject in school.

13. Even before I begin a new topic in mathematics, I feel confident that I will be able to understand it.

14. Mathematics should be very appealing to a student with imagination.

15. I'm looking forward to studying some of the advanced mathematical topics I've heard about.

16. The trouble with mathematics is that it's too theoretical, and not practical enough.

17. I enjoy trying to solve mathematical problems and puzzles.

18. I think I have good ability in mathematics.

19. The average student can't help being bored by mathematics.

20. Mathematics helps us to find out more about the world we live in.

21. In mathematics, you either know what you are doing or you don't; there's no in-between.

22. I feel quite capable of going on to higher mathematics.

23. Unless a mathematics teacher gives a clear explanation of a topic, a student has difficulty.

24. I find mathematics useful in everyday life.

25. Mathematics is very interesting.

26. Mathematics courses are for the bright students, not those who are just average.

27. The only students who should be required to take mathematics are those who need it for a career like engineering or science.

28. Mathematics is an essential part of the background of a well educated person.

29. Most of the students who get good marks in mathematics are "bookworms."

30. You don't have to be a special kind of person who has an abstract mind or have unusually good mathematical talent to enjoy mathematics.

31. In mathematics, more than in any other subject, what a student learns depends on how good the teacher is.

32. Mathematics frightens me.

33. Mathematics is probably not the easiest school subject, but it isn't the hardest either.

34. Homework in mathematics is more difficult than homework in other subjects.

35. The most important thing in mathematics is a good memory.

36. Mathematicians are no more peculiar than doctors, lawyers, or people in other fields.

37. I would take mathematics even if I didn't have to.

38. Even when I understand a mathematical topic fairly well, I find it hard to explain to someone else.

39. Mathematics is basically a very interesting subject, and there is no reason why a student has to find it boring or dull.

40. I get more nervous before a test in mathematics than a test in any other subject.

41. I find mathematics confusing.

42. Mathematics is highly practical as well as theoretical.

43. We always start a new topic in mathematics before I feel sure of the old one.

44. You don't need a special aptitude for mathematics to do well in it.

45. Students who are very good in mathematics are often not interested in other students.

46. An average student can understand mathematics.

47. In mathematics, it isn't necessary for each student to study topics in the same order.

48. In mathematics, I have to memorize because I can't really understand it.

49. If you go about studying mathematics in a sensible way, you usually find it's not too difficult.

50. I like to study interesting applications of mathematics even if they are not part of the assigned course work.

Answer Sheet

HOW DO YOU FEEL ABOUT MATHEMATICS?

DIRECTIONS: Circle "A" or "D" as appropriate.

	Agree	Disagree			Agree	Disagree
1.	A	(D)		26.	A	(D)
2.	A	(D)		27.	A	(D)
3.	(A)	D		28.	(A)	D
4.	A	(D)		29.	A	(D)
5.	A	(D)		30.	(A)	D
6.	(A)	D		31.	A	(D)
7.	(A)	D		32.	A	(D)
8.	A	(D)		33.	(A)	D
9.	A	(D)		34.	A	(D)
10.	A	(D)		35.	A	(D)
11.	(A)	D		36.	(A)	D
12.	A	(D)		37.	(A)	D
13.	(A)	D		38.	A	(D)
14.	(A)	D		39.	(A)	D
15.	(A)	D		40.	A	(D)
16.	A	(D)		41.	A	(D)
17.	(A)	D		42.	(A)	D
18.	(A)	D		43.	A	(D)
19.	A	(D)		44.	(A)	D
20.	(A)	D		45.	A	(D)
21.	A	(D)		46.	(A)	D
22.	(A)	D		47.	A	(D)
23.	A	(D)		48.	(A)	D
24.	(A)	D		49.	(A)	D
25.	(A)	D		50.	(A)	D

(THE ENCIRCLED RESPONSES REPRESENT THE PROPER ONES ACCORD-
ING TO RABINOWITZ!)

APPENDIX B

RAW SCORES

Claremore Junior College

	Control Group							Experimental Group					
Student	Coop. Algebra			Attitude			Student	Coop. Algebra			Attitude		
No.	Pre	Post	Diff	Pre	Post	Diff	No.	Pre	Post	Diff	Pre	Post	Diff
1	26	33	7	45	44	-1	1	18	27	9	27	29	2
2	36	38	2	35	38	3	2	25	31	6	41	43	2
3	26	35	9	30	24	-6	3	31	33	2	38	35	-3
4	12	24	12	14	12	-2	4	36	35	-1	33	34	1
5	18	27	9	25	27	2	5	17	21	4	32	15	-17
6	18	16	-2	36	39	3	6	16	29	13	30	30	0
7	27	37	10	43	46	3	7	30	25	-5	39	31	-8
8	34	40	6	48	42	-6	8	30	38	8	44	48	4
9	21	29	8	28	24	-4	9	28	35	7	39	43	4
10	27	27	0	45	40	-5	10	24	28	4	35	28	-7
11	38	39	1	31	35	4	11	39	39	0	36	42	6
12	25	33	8	47	47	0	12	36	40	4	47	47	0
13	29	38	9	43	43	0	13	23	30	7	33	30	-3
14	26	19	-7	32	36	4	14	30	34	4	38	33	-5
15	16	23	7	32	30	-2	15	27	35	8	44	43	-1
16	32	36	4	35	33	-2	16	22	30	8	32	40	8
17	30	34	4	34	42	8	17	24	34	10	43	40	-3
18	27	33	6	46	44	-2	18	35	32	-3	41	30	-5
19	26	29	3	29	36	7	19	29	36	7	33	40	7
20	17	24	7	28	33	5	20	32	32	0	39	38	-1
			Incomplete Data										
21	30			31									
22	20			30									
23	25			37									
24	10			26									
25	26			26									
26	15			35									

Seminole Junior College

Control Group

Student No.	Coop. Algebra Pre	Post	Diff	Attitude Pre	Post	Diff
1	24	29	5	28	45	17
2	23	26	3	27	31	4
3	31	22	1	34	38	4
4	28	34	6	40	30	-10
5	25	30	5	41	42	1
6	28	31	3	47	48	1
7	19	26	7	27	15	-12
8	33	35	2	45	31	-14
9	33	35	2	47	46	-1
10	28	28	0	24	25	1
11	27	31	4	40	38	-2
12	21	17	-4	31	17	-14
13	17	20	3	34	33	-1
14	28	39	11	41	43	2
15	31	33	2	31	37	6
16	26	32	6	29	28	-1
17	29	39	10	28	33	5
18	29	32	3	39	41	2
19	32	34	2	-	39	-
Incomplete Data						
20	17	-	-	-	-	-
21	22	-	-	-	-	-
22	-	-	-	33	-	-
23	-	-	-	36	-	-
24	17	-	-	44	-	-
25	20	-	-	20	-	-
Foreign Students						
26	27	34	7	27	27	0
27	29	31	2	30	29	-1
28	12	20	8	-	26	-
Incomplete Data						
29	8	-	-	-	-	-

Experimental Group

Student No.	Coop. Algebra Pre	Post	Diff	Attitude Pre	Post	Diff
1	18	21	3	26	31	1
2	24	20	-4	32	18	-14
3	24	19	-5	27	19	-8
4	22	26	4	41	43	2
5	19	25	6	22	22	0
6	28	30	2	28	31	3
7	32	37	5	45	43	-2
8	18	21	3	35	33	-2
9	21	24	3	-	14	-
10	-	12	-	21	21	0
Incomplete Data						
11	28	-	-	-	-	-
Foreign Students						
12	23	32	9	27	25	-2
13	30	27	-3	34	28	-6
14	21	28	7	29	30	1
15	7	23	16	26	28	2
16	12	13	1	36	22	-14
17	19	27	8	35	29	-6
18	30	34	4	33	-	-
19	20	28	8	-	-	-
20	27	29	2	33	-	-
21	11	21	10	31	-	-
22	5	32	27	-	33	-
Incomplete Data						
23	2	-	-	-	-	-

South Oklahoma City Junior College

	Control Group							Experimental Group					
Student No.	Coop. Algebra			Attitude			Student No.	Coop. Algebra			Attitude		
	Pre	Post	Diff	Pre	Post	Diff		Pre	Post	Diff	Pre	Post	Diff
1	34	35	1	41	37	-1	1	35	34	-1	-	-	-
2	31	30	-1	43	45	2	2	25	27	2	35	21	-14
3	34	34	0	38	38	0	3	28	28	0	32	18	-14
4	33	36	3	48	48	0	4	31	10	-21	36	38	2
5	36	35	-1	42	45	3	5	36	37	1	42	46	4
6	33	38	5	44	42	-2	6	22	25	3	43	43	0
7	35	38	3	36	40	4	7	22	20	-2	35	38	3
8	17	17	0	32	39	7	8	36	36	0	27	25	-2
9	29	27	-2	43	43	0	9	39	39	0	40	46	0
10	31	29	-2	40	37	-3	10	31	26	-5	25	29	4
11	37	35	-2	43	43	0	11	23	28	5	34	37	3
Incomplete Data							12	34	34	0	38	40	2
12	23	-	-	28	-	-	13	37	34	-3	42	43	1
13	29	-	-	35	-	-	14	30	38	8	45	47	2
14	23	-	-	40	-	-	15	36	37	1	44	44	0
15	17	-	-	24	-	-	16	29	29	0	35	44	9
16	25	-	-	37	-	-	17	26	27	1	28	34	6
17	19	-	-	31	-	-	18	23	18	-5	35	31	-4
18	29	-	-	44	-	-	19	34	39	5	36	38	2
19	32	-	-	-	-	-	20	24	29	5	41	44	3
Foreign Students							Incomplete Data						
20	18	38	20	17	34	17	21	26	-	-	36	-	-
21	19	29	10	-	-	-	22	23	-	-	31	-	-
Incomplete Data							23	20	-	-	27	-	-
22	18	-	-	23	-	-	24	31	-	-	39	-	-
23	11	-	-	29	-	-	Foreign Students						
							25	26	28	2	15	25	10
							26	33	34	1	39	41	2
							27	-	20	-	29	34	0
							28	10	21	5	-	29	-

Oklahoma State University Technical Institute

	Control Group							Experimental Group					
Student No.	Coop. Algebra			Attitude			Student No.	Coop. Algebra			Attitude		
	Pre	Post	Diff	Pre	Post	Diff		Pre	Post	Diff	Pre	Post	Diff
1	23	27	4	17	23	6	1	33	28	-5	36	39	3
2	26	20	-6	22	17	-5	2	17	18	1	38	28	-10
3	28	30	2	23	28	5	3	32	32	0	43	37	-6
4	15	19	4	25	26	1	4	27	34	7	35	36	1
5	30	35	5	35	22	-13	5	28	28	0	21	20	-1
6	12	13	1	37	36	-1	6	25	28	3	19	23	4
7	26	32	6	34	34	0	7	31	40	9	31	23	-8
8	31	21	-10	32	36	4	8	26	25	-1	29	26	-3
9	24	30	6	43	32	-11	9	26	21	-5	20	17	-3
							10	24	22	-2	33	28	-5
		Incomplete Data							Incomplete Data				
10	25	-	-	42	-	-							
11	30	-	-	37	-	-	11	27	-	-	37	-	-
12	26	-	-	11	-	-	12	25	-	-	33	-	-
13	21	-	-	25	-	-	13	24	-	-	25	-	-
14	25	-	-	40	-	-	14	23	-	-	44	-	-
15	26	-	-	31	-	-	15	34	-	-	40	-	-
16	23	-	-	27	-	-	16	15	-	-	12	-	-
17	18	-	-	31	-	-	17	28	-	-	31	-	-
18	37	-	-	38	-	-	18	19	-	-	20	-	-
19	19	-	-	34	-	-	19	17	-	-	42	-	-
20	24	-	-	40	-	-	20	31	-	-	41	-	-
21	-	26	-	-	32	-	21	26	-	-	-	-	-
22	-	24	-	-	13	-	22	27	-	-	-	-	-
23	-	18	-	-	19	-	23	27	-	-	-	-	-
24	-	38	-	-	29	-	24	17	-	-	-	-	-

APPENDIX C

FORMULAS

FORMULAS

Variance

$\overline{X}$ = mean

Σx^2 = the sum of squared deviations from the mean

ΣX^2 = the sum of squared raw scores

ΣX = the sum of raw scores

n = the number of students

s^2 = variance

$$\Sigma x^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{n}$$

$$s^2 = \frac{\Sigma x^2}{n-1}$$

Student t

$\overline{X}_1$ = mean of control group

$\overline{X}_2$ = mean of experimental group

s_1^2 = variance of control group

s_2^2 = variance of experimental group

n_1 = number of students in control group

n_2 = number of students in experimental group

s_g^2 = largest variance

s_l^2 = least variance

F = value used to test homogeneity of variance

F ratio

$$F = \frac{s_g^2}{s_l^2}$$

n-1 degrees of freedom for each variable

Pooled Variance Formula

used when $n_1 = n_2$ and $s_1^2 = s_2^2$ or

$n_1 \neq n_2$ and $s_1^2 = s_2^2$

degrees of freedom, $df = n_1 + n_2 - 2$

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\left(\dfrac{\Sigma x_1^2 + \Sigma x_2^2}{n_1 + n_2 - 2}\right)\left(\dfrac{1}{n_1} + \dfrac{1}{n_2}\right)}}$$

Separate Variance Formula

used when $n_1 \neq n_2$ and $s_1^2 \neq s_2^2$

Cochran Cox formula used to calculate table values

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\dfrac{s_1^2}{n_1} + \dfrac{s_2^2}{n_2}}}$$

Pearson product - moment correlation

X = raw score for achievement

Y = raw score for attitude

$$r = \frac{\Sigma XY - \dfrac{(\Sigma X)(\Sigma Y)}{n}}{\sqrt{\left(\Sigma X^2 - \dfrac{(\Sigma X)^2}{n}\right)\left(\Sigma Y^2 - \dfrac{(\Sigma Y)^2}{n}\right)}}$$

APPENDIX D

LETTER, DR. RABINOWITZ

THE PENNSYLVANIA STATE UNIVERSITY
201 SOCIAL SCIENCE BUILDING
UNIVERSITY PARK, PENNSYLVANIA 16802

College of Education
Department of Educational Psychology

Area Code 814
865-8303

November 26, 1976

Ms. Annette Cooper
Oklahoma State University Technical
  Institute
900 North Portland
Oklahoma City, Oklahoma 73107

Dear Ms. Cooper:

At your request, I am providing you, in this letter, some information on the mathematics attitude scale which you used in your dissertation.

The scale was originally developed in the late 1950's for a study at Queens College in New York City conducted by Professors G. Crosby and H. Fremont. (Professor Fremont may have a copy of this study, but I do not). The scale was designed to measure attitudes among ninth-grade students studying algebra.

In developing the scale, I was guided by the conceptions of Professors Crosby and Fremont regarding "good" attitudes toward mathematics. In general, they stressed the importance of

-- having confidence in one's ability to handle mathematics
-- perceiving mathematics as inherently understandable
-- recognizing the usefulness of mathematics in many contexts
-- enjoying mathematics and not regarding it as dull,
   uninteresting or excessively difficult.

Items were written to reflect these and related attitudes. The items were keyed using expert judgment, and items on which the experts did not agree were discarded. The present 50-items scale was developed by item analysis from a pool of 70 items, tested on 125 ninth-grade students in junior high schools in a suburban school district and an inner-city school district. In our original study, the K-R #20 reliability of the scale with ninth-graders was .85. Since its original development, the scale has been used with students in the elementary school through graduate school with reliabilities ranging generally from .80 to .91.

Ms. Annette Cooper
November 26, 1976
Page 2

        I have no direct evidence on the validity of the scale. Since it is
a measure of attitude, I believe the most appropriate evidence is an
examination of the content of the items. In addition, empirical studies
using the scale have usually produced meaningful and interpretable results.

                        Sincerely,

                        William Rabinowitz
                        Professor of
                        Educational Psychology

WR:dcc

APPENDIX E

DESCRIPTION OF INSTITUTIONS

DESCRIPTION OF INSTITUTIONS

Claremore Junior College is located in Claremore,
Oklahoma, a city whose population is approximately 12,000.
Claremore is about 30 miles from Tulsa, the second most
populous city in the state. Seminole Junior College is
located in Seminole, Oklahoma, a city slightly smaller
than Claremore. Seminole is located approximately 50
miles from Oklahoma City.

South Oklahoma City Junior College and Oklahoma State
University Technical Institute are located in Oklahoma
City, the state capital and largest city in Oklahoma.
Both schools attract their student bodies primarily
from Oklahoma City and the surrounding suburban communi-
ties. Oklahoma State University Technical Institute,
which offers only technical programs, is a two-year
branch campus of Oklahoma State University, Stillwater,
Oklahoma. South Oklahoma City Junior College is charac-
terized by its mastery approach to learning, and many of
its courses are modularized.

VITA

Annette J. Cooper

Candidate for the Degree of

Doctor of Education

Thesis: AN ANALYSIS OF THE EFFECT OF THE USE OF A HAND-HELD CALCULATOR ON ATTITUDE AND ACHIEVEMENT IN SELECTED COLLEGE ALGEBRA CLASSES

Major Field: Higher Education

Minor Field: Technical Education

Biographical:

Personal Data: Born in Vernon, Texas, March 3, 1941, the daughter of W. C. and Retha B. Orr.

Education: Graduated from Cordell High School, Cordell, Oklahoma, 1959; received a Bachelor of Science degree in Mathematics from Southwestern Oklahoma State University, Weatherford, Oklahoma, 1963; received the Master of Natural Science degree from University of Oklahoma, Norman, Oklahoma, 1970; completed the requirements for Doctor of Education degree at Oklahoma State University, Stillwater, Oklahoma, July, 1977.

Professional Experience: Employed as a mathematics teacher at Putnam City High School, Oklahoma City, Oklahoma, from September 1965 to June 1966; adjunct instructor at Oklahoma State University Technical Institute, Oklahoma City, Oklahoma from June 1968 to January 1971; appointed instructor, January 1971, served as instructor until June 1973, appointed assistant professor, June 1973, currently serving in that position.

Professional Organizations: Oklahoma Junior College Mathematics Association, Association for Institutional Research, Oklahoma Council of Teachers of Mathematics, Oklahoma Technical Society.