THE EFFECT OF THE HAND-HELD CALCULATOR ON MATHEMATICS ACHIEVEMENT, ATTITUDE AND SELF CONCEPT OF SIXTH GRADE STUDENTS

by

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E. W. J.

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Chapter 1

INTRODUCTION

Marked changes are occurring in mathematics instruction as classrooms become more mechanized. Recent technological advances have made available small automatic machines for performing calculations. Such miniaturizations, a result of spin-offs from the space industry, have given the consumer a low cost device that has the capacity to add, subtract, multiply, divide and perform other mathematical operations. Lower costs have enabled consumers at all levels of education to purchase these devices and now many student consumers are utilizing hand-held calculators in the elementary classrooms. Thus, teachers and administrators are placed in the position of having to cope with a situation and make instructional decisions regarding applications about which they have limited knowledge.

As is the case with many technological developments, the impact of the hand-held calculator has been so rapid that there have been few efforts to measure its value or hindrance. Grosswirth contends that hand-held calculators are becoming so evident at all levels of education that the question of whether they should be allowed to intrude is moot; the real problem is what to do with them.[1] He further points out that hand-held calculators are creating a mass of questions

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[1]Marvin Grosswirth, "Calculators in the Classroom," <u>Datamation</u>, XXI (March, 1975), p. 90.

and problems for educators to which there are few answers and solutions.

One of the questions Etlinger poses is whether modern technology is producing a learning facility or a learning crutch.[2] He emphasizes that educators must become sensitive to the effects of modern technology on their students.

Numerous writers have ventured to propose different and sometimes conflicting viewpoints concerning student use of hand-held calculators. An obvious use is that the student can check the accuracy of an answer, thus receiving immediate verification which is an important motivational factor. Denman extends this idea further by proposing that reluctant learners will be lured on by the reward of using machines to check answers and may complete more assignments in less time.[3] Other proponents contend that mini-calculators can be a significant force in moving schools away from "answer-oriented" instruction, freeing both teachers and students for concentration on more important underlying concepts. The critics say that students, especially at the elementary levels, risk becoming so dependent on calculators that they will forget, or fail to learn in the first place, basic computation skills.[4]

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[2] Leonard Etlinger, "The Electronic Calculator: A New Trend in School Mathematics," Educational Technology, XIV (December, 1974), p. 44.

[3] Thelma Denman, "Calculators in Class," Instruction, LXXXIII, 6 (February, 1974), p. 56.

[4] "The Great Calculator Debate," Nation's Schools and Colleges, I, 4 (December, 1974), p. 12.

In spite of divergent viewpoints concerning the potential value of the calculator in the elementary classroom, Higgins predicts that hand-held calculators seem destined to become as omnipresent tomorrow as the inexpensive transistor is today.[5] Along this same line of thinking, Henry Mullish, senior research scientist at New York University's Courant Institute of Mathematical Science was quoted in Nation's Schools and Colleges as having made the following prediction:

> Within the next decade, grade school and college students probably will wear miniaturized five-function calculators on their wrists. Desks in colleges and grade schools will not be considered complete unless they have scientific calculators built into them.[6]

In summary, it appears that there is a need for statistical data of an experimental nature on the use of the hand-held calculator in the elementary classroom. Grosswirth supported this idea when he said, "hand-held calculators cannot be ignored. They are not a fad or a gimmick but a serious factor with which educators must contend."[7]

THE PROBLEM

Purpose of the Study

This study was designed to investigate the effects of the use of hand-held calculators on the mathematics achievement, attitude and

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[5]Jon L. Higgins, "Mathematics Programs are Changing," The Education Digest, XL (December, 1974), p. 57.

[6]"1984: A Calculator on Every Wrist and in Every School Desk, Too," Nation's Schools and Colleges, I, 4 (December, 1974), p. 13

[7]Grosswirth, op. cit., p. 95.

self concept of sixth grade students. The null hypothesis for the study is stated below.

Null Hypothesis

There is no difference in the mathematics achievement, attitude and self-concept of students using the hand-held calculator during the learning period and students performing without the use of the hand-held calculator as measured by pretest/posttest scores on the Science Research Associates Assessment Survey, and posttest scores on the Attitude Toward Arithmetic Scale and the Piers-Harris Children's Self Concept Scale.

Need for the Study

Nationally, scores on mathematics tests have been dropping for several years, especially in such basic skills as addition, subtraction, multiplication and division. For example, in California the results of the new math program in 1969 showed that within two years the average scores recorded for sixth graders on standard math tests dropped nearly twenty percent. Results from an investigation made in Iowa schools revealed that mathematics achievement in grades six and eight in 1973 was inferior to the achievement of students in 1936, 1951-55 and in problem solving in 1965.[8] It appears, then, that many teaching strategies, materials and devices have not been

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[8]Stephen Alan Roderick, "A Comparative Study of Mathematics Achievement by Sixth Graders and Eighth Graders, 1936 to 1973, 1951-55 to 1973, and 1965 to 1973" (unpublished Doctor's dissertation, University of Iowa, 1973).

as effective as they might have been. Results from this investigation could be used by school administrators in Norfolk Public Schools, Portsmouth City Schools, as well as by decision makers in other areas as a source of information. In addition, results from this research could provide teachers with statistical data to share with parents in support of the decision to discourage or permit the use of the calculator in the classroom.

The need for this research is further justified on the basis that few controlled studies utilizing the hand-held calculator have been conducted with elementary students. In view of the scarcity of data, some reflections on the following questions may be made.

Are there potential educational disadvantages connected with the use of the calculator? Are there more compelling reasons for using calculators in elementary classrooms other than the fact that students themselves are acquiring and using them? Will slow students be able to understand the basic mathematical principles more effectively? Will the calculator be suitable for solving verbal problems? Will the progress of a lesson be slowed down by computational activity? Will the use of calculators encourage and promote the study of mathematics? These are some of the questions that must be answered. The responsibility of researching and evaluating the devices produced by technology belongs to the school personnel who are striving to upgrade the achievement of students.

Limitations of the Study

1. This study was limited to three sixth grade classes in the Norfolk Public Schools and three sixth grade classes in the Portsmouth City Schools.

2. The duration of this study was limited to nine weeks during the Fall semester of 1975.

BASIC ASSUMPTIONS

The basic assumptions underlying this study were as follows:

1. Science Research Associates test results from the Norfolk Public Schools' Testing Department were reliable and accurate.

2. Science Research Associates test results from the Portsmouth City Schools' Testing Department were reliable and accurate.

3. The instruments selected and procedures used provided a systematic means for collecting data from which the investigator could draw valid conclusions.

ORGANIZATION OF THE STUDY BY CHAPTERS

The introduction, purpose of the study, null hypothesis, need for the study, limitations of the study, basic assumptions and organization of the study by chapters are described in Chapter 1.

A review of related research studies and selected literature are presented in Chapter 2.

Methods and procedures, the population sample, measuring instruments, description of the calculator, teacher orientation, student orientation, classroom procedures, sources and collection of data and treatment of data are presented in Chapter 3.

The analysis and validation of the null hypothesis and sub-hypotheses are presented in Chapter 4.

The final chapter presents a summary of the research, conclusions and recommendations.

Chapter 2

REVIEW OF THE LITERATURE

Innovative educators have for many years been attempting to improve the achievement, attitude of and self-concept of students in mathematics courses through the use of various devices, materials and other strategies. A flood of aids for this purpose appeared on the market following the launching of Sputnik. As these devices have assumed a major role in mathematics instruction, great concern has been generated in regard to their efficacy. Though empirical based research has not indicated conclusively the benefits of many of these aids, they continue to be used in classrooms throughout the United States and appear to be gaining acceptance. One such device which has been used in both controlled and exploratory situations is the calculator. Records on its appearance in the classroom date back beyond 1926.[9] As technological advances are made, research on the newer models periodically appear in the literature. One of the latest models, the hand-held calculator, has precipitated the current revival of interest.

For purposes of this chapter, the first section describes research relative to classroom experiments with the hand-held calculator. The second part reviews literature on the use of desk calculators in mathematics instruction from 1960 to the present. Selected literature

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[9]F. R. Longstaff, R. Stevens, and A. J. King, "Desk Calculators in the Mathematics Classroom," (paper presented at the Canadian Conference on Educational Research, June, 1968).

on the use of other manipulative devices, teaching tools and learning aids is presented in the third section. In this review, the effectiveness of each instrument is discussed in terms of its effect on attitude, self-concept and achievement.

HAND-HELD CALCULATOR STUDIES AND REPORTS

A preview of the literature revealed several accounts of projects designed for student utilization of the hand-held calculator in the classroom. Only one project or study involving elementary students could be located and only one controlled investigation involving intermediate students could be found. All are discussed in this section.

In a recent investigation, Spencer sought to determine what effect an instructional program utilizing the hand-held calculator would have on the computational skill, the reasoning ability and the total arithmetic achievement of intermediate pupils in an "open-concept" elementary school. A sample of forty fifth graders and forty-four sixth graders was randomly assigned to either an experimental or control group at each grade level. The experimental group was allowed to use the calculator during the mathematics period which lasted from thirty-five to forty minutes a day, four days a week for the duration of an eight week study. Findings indicated a significant difference between the experimental and control groups on the reasoning test at grade five in favor of the experimental group. No other significant differences were found between the sexes for this grade level. In grade six the data indicated a significant difference between the groups in both computation skills and total arithmetic achievement. Again the experimental group showed greater gains than the control group. No significant differences were found, however, between sexes. Spencer concluded:

> Proper utilization of the calculator could remove the tedious task of drill and provide more instructional time for developing reasoning concepts. This new tool could possibly increase the arithmetic computation and reasoning levels of elementary children. In essence, the hand-held calculator as a technological tool is calling for a reclarification of the educational institution in relation to change in society.[10]

Hawthorne and Sullivan gave an account of a classroom experiment involving elementary students in which the major goal was to try to discover how (and if) the calculator could enrich, supplement, support and motivate the regular program. In September 1973, each student in a sixth grade class in each of two schools was provided a hand-held calculator to use during mathematics instruction for an entire school year. At the end of the treatment, project evaluators theorized that the devices had no inherent ability to support and motivate mathematical study; however, the standardized testing portion of the project revealed that the mean scores of the group of students using calculators were higher on the concepts and computation

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[10] Jo Ann Nora Spencer, "Using the Hand-held Calculator in Intermediate Grade Arithmetic Instruction" (unpublished Doctor's dissertation, Lehigh University, 1974).

sections than were the corresponding scores for the students not using the calculators.[11]

On a more advanced level, Menlo College conducted a program utilizing pocket calculators. Leake summarized the effects of the use of these devices by pointing out that although no statistical data of an experimental nature were available, the six professors teaching the nine mathematics, science and business classes had very strong feelings about the positive aspects of this approach. They felt that students, because of the logic system of the calculators, learned more about the "why" of the material learned. The speed of the calculators had allowed students to cover more material with far more realistic problems that did not have neat answers. The staff also claimed that learning deficiencies in the students were discovered more quickly than in traditional courses. Leake further urged controlled studies at all levels to see what impact pocket calculators have had on mathematics education.[12]

Sosebee and Walsh attempted to assess the impact of the use of calculators on introductory chemistry grades. The use of pocket electronic calculators in examinations was a student option. Out of four examinations, students who use calculators scored higher on every test than those who did not. The investigators felt that calculators

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[11]Frank S. Hawthorne and John J. Sullivan, "Using Hand-held Calculators in Sixth Grade Mathematics Lessons," New York State Mathematics Teachers' Journal, XXV, 1 (January, 1975), pp. 29-31.

[12]Lowell Leake, "Calculators in the Classroom," Mathematics Teacher, LXVII, 3 (March, 1975), p. 226.

did play a major role in the determination of the grades and that the obvious answer to the problem of one group having an advantage over the other was to either prohibit their use or make them available to all students. An alternative might be to design examinations with the knowledge that using a calculator provides a clear cut advantage to those who have access to them.[13]

DESK CALCULATOR STUDIES

A precursor to the hand-held calculator is the desk calculator. It has been utilized in studies which have been conducted with different grade levels and with different types of students. Some of these investigations are discussed in this section.

In the early sixties, several fourth, fifth and sixth grade classes in a California school system participated in an experimental program utilizing the calculator. There was an attempt to determine the extent to which use of this device would stimulate the learning of arithmetic skills. Observations indicated that elementary students readily learned to operate the calculators and were motivated. Also, the tool tended to reinforce understanding and achievement in basic arithmetic skills as well as to foster better work habits.[14] Although

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[13] Jackson B. Sosebee, Jr. and Lola Mae Walsh, "Pocket Calculators and Test Scores in Introductory Chemistry," Journal of College Science Teaching, IV, 5 (May, 1975), p. 324.

[14] Lois L. Beck, "A Report on the Use of Calculators," The Arithmetic Teacher, VII, 2 (February, 1960), p. 103.

the observer appeared enthusiastic in the writing, no empirical evidence was presented.

Longstaff, Stevens and King presented a report on the use of the calculator as a learning aid in an experimental study. The research was designed to test the use of calculators with two groups of ninth grade students and one group of fifth grade students in three different instructional settings in terms of measurable changes that related to the students' ability to do mathematics and their self-confidence and attitudes toward the subject. Experimental and control classes were designated for each group and in addition, one ninth grade group included a class to control for the "Hawthorne effect". In all three groups there were no significant differences shown in improvement in mathematical skills. In attitude toward mathematics, however, the experimental group showed greater increases than the Hawthorne and control groups at one of the schools. At another school, the control group showed greater increases in self-confidence and attitude than the experimental group. Findings for the grade five students favored the experimental group for self-confidence and attitude toward mathematics. The desk calculators appeared to have no significant effect upon the ability to solve mathematical problems for any of the three groups. What did improve for the ninth grade students was their classroom behavior. The investigators offered the following explanation:

> With the advent of the calculators, the energy and interests were vented upon the machines in a teacher-approved manner rather than on each other and the teacher in a way that disrupted the class.

> The machines provided a diverting interest to supplement low motivation with the result that the classroom atmosphere became calmer and more controllable. For the teachers, two main results were visible, an increase in productivity and an improvement in classroom behavior.[15]

A study on the effect of the rotary calculator on achievement in grades six, seven and eight were conducted by Durrance.[16] Related purposes were to determine the type of computational learning difficulties that were being encountered by pupils and to evaluate the effect of the calculator upon the correction of the learning difficulties. Data revealed that the calculator had no effect in any area of any grade except that of reasoning for the seventh grade. Learning difficulties were identified; however, the calculator had no effect on the correction of the learning difficulties in any grade level. Furthermore, there was no proof that the use of the calculator significantly enabled a student to achieve in arithmetic.

Ellis and Corum conducted a study to determine the effects of calculators upon the achievement, attitude and academic motivation of students in mathematics classes designed for low achieving senior high students. Results from objective measures with both experimental and control classes revealed no statistically significant gains in the areas of mathematical achievement. A more favorable attitude toward mathematics and a weaker degree of academic motivation were recorded

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[15]Longstaff, op. cit., p. 4-6.

[16]Victor R. Durrance, "The Effect of the Rotary Calculator on Arithmetic Achievement in Grades Six, Seven and Eight" (unpublished Doctor's dissertation, George Peabody College for Teachers, 1964).

for both groups at the conclusion of the study. From taped interviews with teachers, it was indicated that a more stimulating environment existed in the experimental class.

The investigators further reported the following:

> In this study, as in most research studies, it was not possible to identify all of the contributing influences. However, it appeared from the research findings that the general learning environment permeating the mathematics laboratory was more important to student achievement than were the calculators or any other known single factor.[17]

Keough and Burke reported their findings from an experimental study conducted for the purposes of (1) determining the feasibility of using electronic calculators to improve mathematics instruction; (2) determining whether or not curriculum related materials could be developed to make the electronic calculator a valuable tool for students; and (3) determining if there were applications which would assist in the teaching areas related to mathematics. They concluded that the use of the calculator as an instructional tool resulted in significantly greater achievement for the experimental group as compared to the control group. Also that the use of the electronic calculator can facilitate mathematics instruction in eleventh and twelfth grade classes.[18] No findings were reported for the other purposes.

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[17] June Ellis and Al Corum, Functions of the Calculator in the Mathematics Laboratory for Low Achievers, U. S., Educational Resources Information, ERIC Document ED 040 847, 1969.

[18] John L. Keough and Gerald W. Burke, Utilizing an Electronic Calculator to Facilitate Instruction in Mathematics in 11th and 12th Grades, U. S., Educational Resources Information Center, ERIC Document ED 037 345, July, 1969.

In a more recent investigation, Cech tested the effect of the use of desk calculators on attitude and achievement with low achieving ninth graders. Analysis of pretest, posttest data from the experimental and control groups indicated that the use of calculators in the instructional program with ninth grade, low achieving mathematics students did not improve their attitudes toward mathematics nor did it improve their computational skills. Cech offered the following general comments:

> Low achieving, ninth grade students are subjected to a host of social, academic and physiological pressures. These shape their attitudes toward the study of mathematics and are monumental when compared to the salutary effects of the use of the calculator for a short time may have in improving their attitudes. Though the calculator may be of no value in improving computational skills, this does not preclude its desirability when other objectives are being sought.[19]

A research report made by Advant indicated the results of a study on the effect of the use of desk calculators on achievement and attitude of children with learning and behavior problems. The eighteen subjects, whose ages ranged from twelve through fifteen years and whose I.Q.s ranged from sixty-eight to 116, were not compared with an experimental group, but were pretested and posttested. Comparison of these data showed significant increases in student interest,

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[19]Joseph P. Cech, "The Effect of the Use of Desk Calculators on Attitude and Achievement with Low Achieving Ninth Graders," The Mathematics Teacher, LXV, 2 (February, 1972), pp. 183-186.

positive attitudes toward mathematics and reduction in disruptive behavior.[20]

Stocks conducted an investigation to determine the efficacy of teaching educable mentally retarded subjects the concept of long division facilitated by the use of an electric desk calculator. All subjects demonstrated an improvement in scores between the pretest and posttest sessions. The criterion measure removed from the context of the machine indicated a transfer to paper-pencil situation. The investigator concluded that:

> If supportive media matches the social and mental sophistication of the learner, the learning environment will be more sustained interest. It seems apparent that the entire area of academic offerings must be reevaluated in terms of appropriate instructional procedures.[21]

In an effort to determine whether the use of the electric calcualtors offered an effective remedy for the lack of success and for the corresponding negative attitude of the low achiever, Ladd conducted an experimental study. A secondary purpose was to examine the relationship between mathematics achievement, intelligence quotients

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[20]Kan Advant, "The Effect of the Use of Desk Calculators on Achievement and Attitude of Children With Learning and Behavior Problems," (paper presented at the Fourteenth Annual Conference of the Ontario Educational Research Council, December, 1972).

[21]Sister Tina Marie Stocks, "The Development of an Instructional System Which Incorporates the Use of an Electric Desk Calculator as an Aid to Teaching the Concept of Long Division to Educable Mentally Retarded Adolescents" (unpublished Doctor's dissertation, Columbia University, 1972).

and mathematics attitude. Findings led to the following conclusions:

> A ninth grade mathematics course for low achievers in mathematics which is organized into a sequence of short lessons, which contains problems selected from local businesses and which is taught by experienced teachers in small classes does result in a significant improvement in the mathematics attitude and achievement of the students. The addition of electric calculators to the course of instruction described above does not increase or decrease the improvement in attitude or in achievement. Mathematics attitude is not a useful predictor of mathematics achievement. The intelligence quotient is not a useful predictor of mathematics attitude. The intelligence quotient is a predictor of mathematics achievement; however, the variance in mathematics achievement accounted for by intelligence quotients is small.[22]

Gaslin reported the results of a ten-week study which investigated the use of electronic calculators to perform basic operations with rational numbers in ninth grade mathematics classes. Conclusions drawn were that the use of an "alternative algorithm set" with the calculator appeared to be a viable alternative to use of the "conventional algorithm set" with or without the calculator.[23]

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[22]Norman E. Ladd, "The Effects of Electric Calculators on Attitude and Achievement of Ninth Grade Low Achievers in Mathematics" (unpublished Doctor's dissertation, Southern Illinois University, 1973).

[23]William L. Gaslin, "A Comparison of Achievement and Attitudes of Students Using Conventional or Calculator Based Algorithms for Operations on Positive Rational Numbers in Ninth Grade General Mathematics," (paper presented at the Annual Meeting of the American Educational Research Association, April, 1974).

RESEARCH RELATED TO OTHER MANIPULATIVE AIDS

The calculator as a type of manipulative aid may be categorized with other such devices. Many prominent educators in the field of mathematics education have strongly supported the use of manipulative aids and devices in the teaching of mathematics. This support has been based upon prominent learning theories subscribed to by learning psychologists. Though the rationale seems to be educationally sound, research studies have presented diverse findings on the effectiveness of some of these aids. A selected review of some of these studies was presented in this section.

Fennema conducted a study to determine the relative effects of utilizing a concrete and a symbolic model in the learning of a mathematical principle. Subjects in a second grade population were assigned to three treatment groups. Group 1 received instruction in the principle with a symbolic model; group 2 received instruction in the principle with a concrete model while group 3 served as a control. Analysis of the data revealed that there were no significant differences in the overall learning of a mathematical principle when learning was facilitated by a meaningful concrete or a meaningful symbolic model. Fennema concluded that the children were able to learn a mathematical principle by using only a symbolic or a concrete model when that model was related to knowledge the children had. Children who had learned with a symbolic model could transfer this learning to solving untaught symbolic instances of the principle significantly better than could children who had learned with a concrete model.[24]

In some of the larger school systems, experiments have been performed to determine potential use of the computer as a teaching and learning aid. One such study was conducted by Ronan who had an experimental group use the computer as a computational tool, as a teaching tool and as a learning tool. At the conclusion of the study, there were significant differences between the mean achievement scores of the experimental and control groups involving mathematical skills and logic and reasoning ability. There were no significant difference in the ability to apply mathematical concepts and in problem solving.[25]

Another investigator, Hatfield, designed a study to observe the effects of the computer when used as a tool to learn mathematics. Seventh grade students in the computer treatment group wrote computer programs involving the same mathematical content taught in the non-computer group. After a two year period, positive results led the investigator to support computer-assisted problem solving in grade seven mathematics, particularly for the study of number theory, for

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[24]Elizabeth H. Fennema, "A Study of the Relative Effectiveness of a Meaningful Concrete and a Meaningful Symbolic Model in Learning a Selected Mathematical Principle" (unpublished Doctor's dissertation, The University of Wisconsin, 1969).

[25]Franklin D. Ronan, "A Study of the Effectiveness of a Computer When Used as a Teaching and Learning Tool in High School Mathematics" (unpublished Doctor's dissertation, The University of Michigan, 1971).

the ability to solve unfamiliar word problems, for the performance on problem items, and for students identified as high and average achievers.[26]

On the high school level, Mandelbaum studied the effects on achievement and attitude of the computer as a problem solving tool. Four groups of low performing tenth grade general mathematics students were combined to form an experimental and a control group. The experimental group learned to use the computer as a problem solving tool in conjunction with the regular course of study while the control group had no access or exposure to the computer. Following the treatment, results revealed no significant differences in achievement in computation, concepts or application nor any significant differences in attitude.[27]

Rich attempted to assess the value of multibase arithmetic blocks and cuisenaire rods with seventh grade inner-city students. Following the pretest, daily instructions were centered around the learning aids. At the end of the treatment period, posttests were administered. Conclusions drawn by the researcher were that mathematics instruction centered around the use of multibase arithmetic blocks and

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[26]Larry L. Hatfield, "Computer Assisted Mathematics: An Investigation of the Effectiveness of the Computer Used as a Tool to Learn Mathematics" (unpublished Doctor's dissertation, University of Minnesota, 1969).

[27]Joseph Mandelbaum, "A Study of the Effects, on Achievement and Attitude, of the Use of the Computer as a Problem Solving Tool with Low Performing Tenth Grade Students" (unpublished Doctor's dissertation, Temple University, 1973).

cuisenaire rods did not negatively affect mathematics achievement, computational ability and understanding of concepts.[28]

In contrasting two types of instruction in fourth grade mathematics, Shea randomly selected an experimental and a control group to participate in an experiment concerned with calculator flow-charting instruction based on the use of the Olivetti-Underwood Divisumma 24 versus conventional instruction. The basic purpose was to determine if there would be any effect on the achievement and attitude of students involved in the study. After the pretest and treatment period, posttests were administered. Shea concluded that calculator flow-charting instruction was superior to conventional textbook type instruction for improving arithmetic computation and arithmetic applications of male students. Also, that calculator flow-charting instruction was not superior to conventional textbook type instruction for effecting gains in arithmetic concepts and arithmetic applications of females, nor in improving attitudes of students.[29]

Johnson utilized physical models and instruments in his efforts to investigate the effects of varying concrete activities on achievement of objectives in perimeter, area, and volume. Three groups, categorized on the basis of reading ability, age and sex, received different

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[28]Littleton W. Rich, "The Effects of a Manipulative Instructional Mode in Teaching Mathematics to Selected 7th Grade Inner-City Students" (unpublished Doctor's dissertation, Temple University, 1972).

[29]James F. Shea, "The Effects on Achievement and Attitude Among Fourth Grade Students Using Calculator Flow-Charting Instruction vs. Conventional Instruction in Arithmetic" (unpublished Doctor's dissertation, New York University, 1973).

degrees of treatment. At the end of the six week period, posttests were administered to all students. The results provided evidence that a high degree of concreteness yields higher means on achievement of objectives upon immediate measure as well as higher retention on subsequent measures.[30]

An experimental study utilizing a mathematical device called a tryab was conducted by Eudy to determine the effect on the arithmetic achievement of primary students. A secondary purpose was to determine which concepts could best be taught with this device. The use of the tryab was an attempt to develop mathematical understandings resulting from the correlation of concrete and symbolic mathematics. Activities with the tryab moved from manipulative experiences with the concrete to the use of visual models and then to pencil and paper type abstract solving methods. An analysis of the test scores of the experimental and control groups indicated the concepts "inequalities" and "geometry" were taught most effectively. Results of the pretest and posttest scores yielded a difference in gain scores, however, the difference was not significant.[31]

Purser sought to determine if certain manipulative activities using measuring instruments were significantly associated with student

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[30]Robert L. Johnson, Jr., "Effects of Varying Concrete Activities on Achievement of Objectives in Perimeter, Area, and Volume by Students of Grades Four, Five and Six" (unpublished Doctor's dissertation, University of Colorado, 1970).

[31]Elaine H. Eudy, "The Effectiveness of a Mathematical Device Called a Tryab on the Arithmetic Achievement of Primary Students" (unpublished Doctor's dissertation, The University of Mississippi, 1973).

gains in achievement and retention scores in mathematics with high, medium, and low ability seventh grade students. Students in the experimental group used learning packages that utilized manipulative activities, rulers, and micrometers while the control group used learning packages that utilized paper-pencil type problems. Results from the analysis of data for the experimental and control groups indicated that the students of all ability levels in the experimental group achieved significantly higher scores on the posttest and retention test than those in the control group. Boys and girls did equally well on the posttest; however, girls scored significantly higher on the retention test than did boys.[32]

Ashby reported findings from a study on the slide rule and its effect upon interest, computation and reasoning among seventh grade mathematics students. Results revealed a statistically significant difference between the means of the experimental and control groups for computational interest. There was no significant difference between the means of the experimental and control groups in mathematical reasoning and computational abilities, mechanical interest, scientific interest and arithmetic achievement.[33]

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[32]Jerry D. Purser, "The Relation of Manipulative Activities, Achievement and Retention in a Seventh-Grade Mathematics Class: An Exploratory Study" (unpublished Doctor's dissertation, University of Georgia, 1973).

[33]Willie R. Ashby, "The Slide Rule: Its Effect Upon Interest, Computation and Reasoning Among Seventh Grade Mathematics Students" (unpublished Doctor's dissertation, East Texas State University, 1974).

Summary

The literature related to the use of the hand-held calculator and other devices has been rather limited. Research findings in terms of effectiveness have been specific, though many studies did not reveal significant improvement in achievement or attitudes. With the research on the hand-held calculator, positive results were obtained in many areas of mathematics such as reasoning and basic skills. Each investigator recommended the need for further documentation of its effectiveness as a teaching device or learning aid. Though few of the investigators examined the effect of the use of the calculator on the self concept of students, many educators have speculated that if achievement improves so will attitude and self-concept. In light of the foregoing results of the research studies reviewed and recommendations made by the researchers, this study was designed to investigate the effects of the hand-held calculator on mathematics achievement, attitude and self-concept of sixth-grade students in self-contained classrooms.

Chapter 3

METHODS AND PROCEDURES

The purpose of this chapter was to describe the methodology and procedures used in the conduct of the study. These are discussed under the following headings: (1) population sample; (2) measuring instruments; (3) description of calculator; (4) teacher orientation; (5) student orientation; (6) classroom procedures; (7) sources and collection of data; and (8) treatment of data.

POPULATION SAMPLE

The sample for this experimental study was composed of one hundred seventy-one sixth grade students from Lindenwood Elementary School in Norfolk, Virginia and Cavalier Manor Elementary School in Portsmouth, Virginia. Both schools accommodated students from low to middle socio-economic areas and from multi-ethnic backgrounds. These school systems were selected because of their availability to the investigator for study. Like many other systems throughout the nation, numerous ongoing programs were being conducted. In order not to interfere with these programs and also to have an adequate sample, it was necessary to accept three intact classes, two experimental and one control, from each of the schools. Since there were only thirty calculators available for each school, principals were asked not to assign additional students to the experimental classes. It was possible then, to apply treatment to an equal number of students from each school.

The remaining classes served as the controls. Treatment groups were identified by pulling slips from a bag. Fifty-eight female and fifty-five male students made up the experimental classes. Thirty-three female and twenty-five male students were included in the control classes. A pictorial representation of the general research design is shown in Figure 1.

MEASURING INSTRUMENTS

There are numerous instruments which measure mathematical achievement. Selection of the instruments for this study was based upon the purposes for which the outcomes of the study were to be used and the validity and reliability of the tests. An appropriate instrument, Science Research Associates Assessment Survey administered to all sixth grade students in each school system, was selected to determine computation skills developed and mathematical concepts learned by both experimental and control groups.

Science Research Associates Assessment Survey, Achievement Series, Forms E, F Green Level

This instrument was developed by Robert A. Naslund, Louis P. Thorpe and D. Welty Lefever. The multilevel edition consists of separate but overlapping color coded levels of graduated difficulty designed for use in grades four through nine. It covers major concepts included in the Norfolk and Portsmouth curricula. To develop the appropriate norm, the standardization research used the results of 155,567 students nationwide. All of the students tested were selected

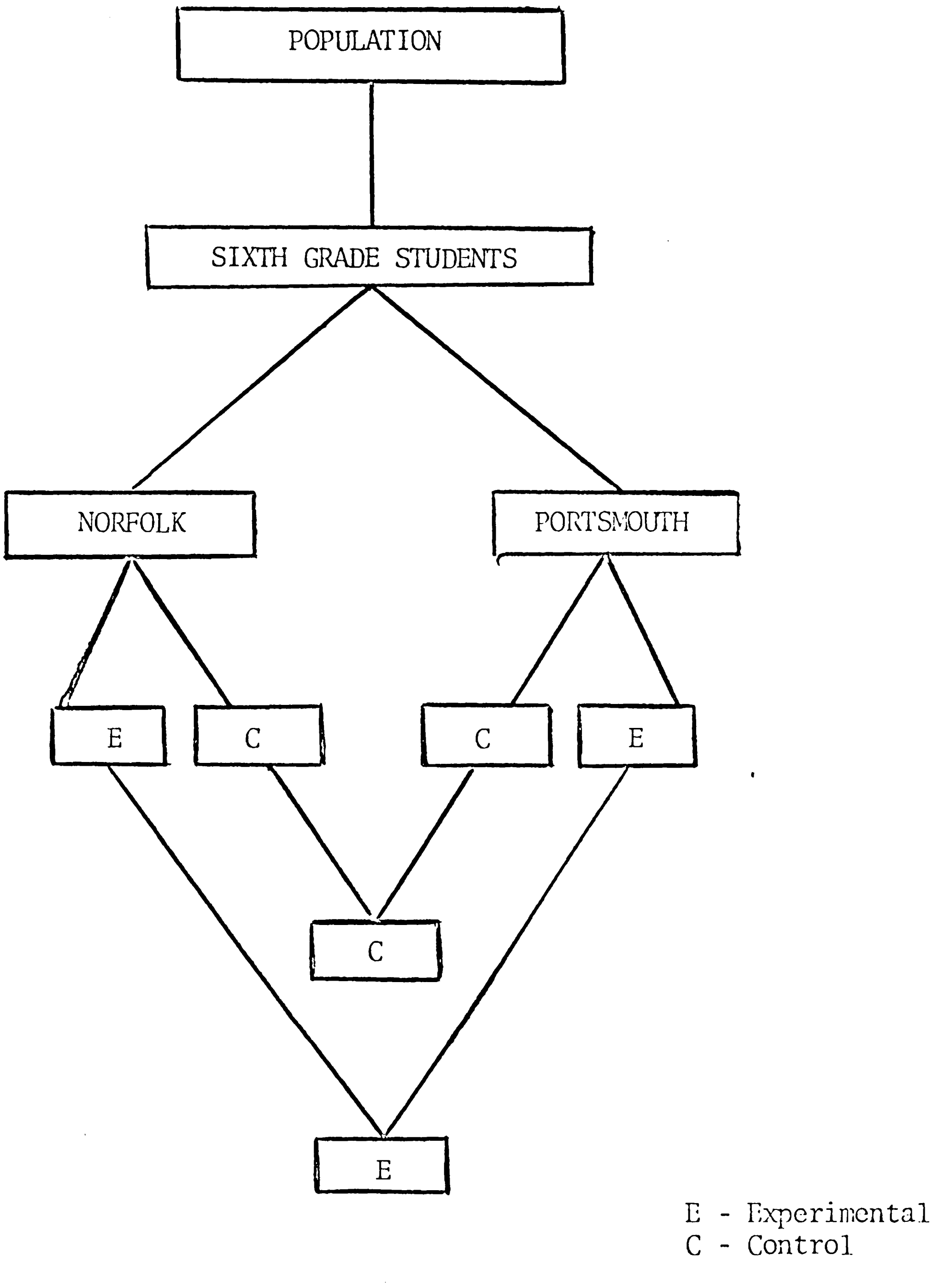

Figure 1

General Research Design

randomly by computer, first by district, then by school within district, and finally by class within school. Nonpublic schools in the same geographic areas as the public schools were also sampled. Valid test content was provided through curriculum outlines and basal texts. Item writers prepared test questions which were reviewed, edited and pretested in school districts across the United States. Statistical and content criteria were used to select those items which would be valid for a battery. In the area of mathematics, the total score is based on concept and computation subtests. /Concept questions measure understanding of basic numeration and mathematical operations as well as knowledge and application of concepts in measurement, geometry and problem solving. Computation questions measure ability to add, subtract, multiply and divide whole numbers. The average Kuder Richardson-20 reliability for mathematical concepts was reported as .86 and for mathematical computation as .91. For total mathematics, a Kuder Richardson-20 reliability of .94 was indicated.[34]

Multilevel editions are standardized in such a way that they can be used in grades above and below those for which they were originally intended. Inasmuch as one form of the test is already given to sixth grade students in both school systems, an alternate form should provide a certain amount of compatibility. Further justification

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[34]Robert A. Naslund, Louis P. Thorpe, and D. Welty Lefever, Science Research Associates Assessment Survey, Achievement Series, Test Coordinators Handbook (Chicago: Science Research Associates, Inc.), 1975.

for the appropriateness of this test is that it is not unfamiliar to the students.

A search of the literature shows that numerous instruments have been employed in appraising attitudes in the learning of mathematics. The instrument selected for this study was Dutton's Attitude Toward Arithmetic Scale. It contains twenty-seven Likert-type items which assess attitude toward mathematics. In a sample of 346 students in grades six through eight, a Spearman-Brown test-retest reliability of .84 was obtained.[35] This instrument was deemed appropriate since it is already used in the Norfolk school system and appeared to be a medium through which students could freely express themselves.

Among the instruments available for measuring self-concept is the Piers-Harris Children's Self Concept Scale. To judge the homogeneity of the test, the Kuder Richardson Formula 21, which assumes equal difficulty of items, was employed with resulting coefficients ranging from .78 to .93.[36] These data provided adequate reliability for selection of this particular instrument. Additionally, it is already used in the Norfolk school system and also provided items for which data were needed.

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[35]Wilbur H. Dutton and Martha P. Blum, "The Measurement of Attitudes Toward Arithmetic With a Likert-Type Test," Elementary School Journal, 68 (February, 1968), pp. 259-264.

[36]Ellen V. Piers, Manual for The Piers-Harris Children's Self Concept Scale (Nashville: Counselor Recordings and Tests), 1969.

DESCRIPTION OF CALCULATOR

There are numerous brands of hand-held calculators which perform a variety of operations. Criteria for selection of the instrument for this study were the capacity to add, subtract, multiply, divide and display a floating decimal. Thus the Monroe Model 30 Portable Electronic Display Calculator was chosen. This device has an 8-digit display capacity, automatic constant multiplication and division, sequential and percent calculators, floating (F) and + (Add Model) decimal selection, zero suppression for longer operating time, overflow, underflow and a glarefree planar display. The keyboard and the angle of the display facilitate desk top as well as hand-held operation. It has a converter/charger for operation on AC current, is six inches long, three and one-half inches wide and two inches high and weighs eleven ounces.[37]

To provide for a convenient source of energy, five horizontal extension outlets containing six sockets were assembled for use with the thirty calculators which were used by each class during different periods of the day. A locked facility for storage was made available by the principal of each school since the use of the calculators was restricted to this experimental study. Not only was this a safety precaution, but also a method of preventing unauthorized use of the

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[37]Monroe, The Calculator Company, Operating Instructions, Model 30, Portable Electronic Display Calculator (Orange, New Jersey: Litton Business Systems, Inc.), 1974.

machines. Monroe, The Calculator Company, furnished the calculators for this experiment without charge.

TEACHER ORIENTATION

In the conduct of an experimental study, it is essential that all persons involved understand their roles if valid and reliable results are to be obtained. To reduce teacher variability, an orientation workshop was conducted for participating teachers from each school during the first week of October, 1975. During this time, instructions on the operation and care of the calculators were given by the investigator. Instructional activities and lesson plans for the duration of the experiment were developed. A schedule of the experiment and learning objectives for the lessons were prepared and distributed to each teacher and both principals (see Appendixes B and C). All calculators and calculator-related materials were distributed to the teachers. Although teacher training and competency were not factors in this investigation, profiles of teachers are provided in Table 13 (Appendix E).

STUDENT ORIENTATION

At the beginning of the student orientation, one hand-held calculator for each student was provided. To familiarize students with the type of calculator they would be using, each was allowed time to perform several simple computations. Specific instructions were then given as to when the calculator was to be used. A discussion on the care of the instrument and its placement in a special box at the end of the mathematics period completed the orientation for students.

CLASSROOM PROCEDURES

As the experiment proceeded, each teacher maintained a log of the time students used the calculators each day. Students were encouraged to utilize the instrument as often as possible during the fifty-five to sixty minute mathematics class periods. Except for tests, experimental students were free to use the calculators to experiment with mathematical ideas, to develop understanding through repeated operations, to check pencil and paper calculations, to find errors in problems and to decrease the time needed to solve difficult computations. Students in the control group worked all problems using pencil and paper. No homework was to have been given to either group. Because of parental objection to the students not having homework, teachers assigned study of and practice concerning work done in class. All classes met each day for five days per week. The treatment period lasted from October 15, 1975 to December 18, 1975. Because one day was used for student orientation, the experimental group finished one day later than the control group.

SOURCES AND COLLECTION OF DATA

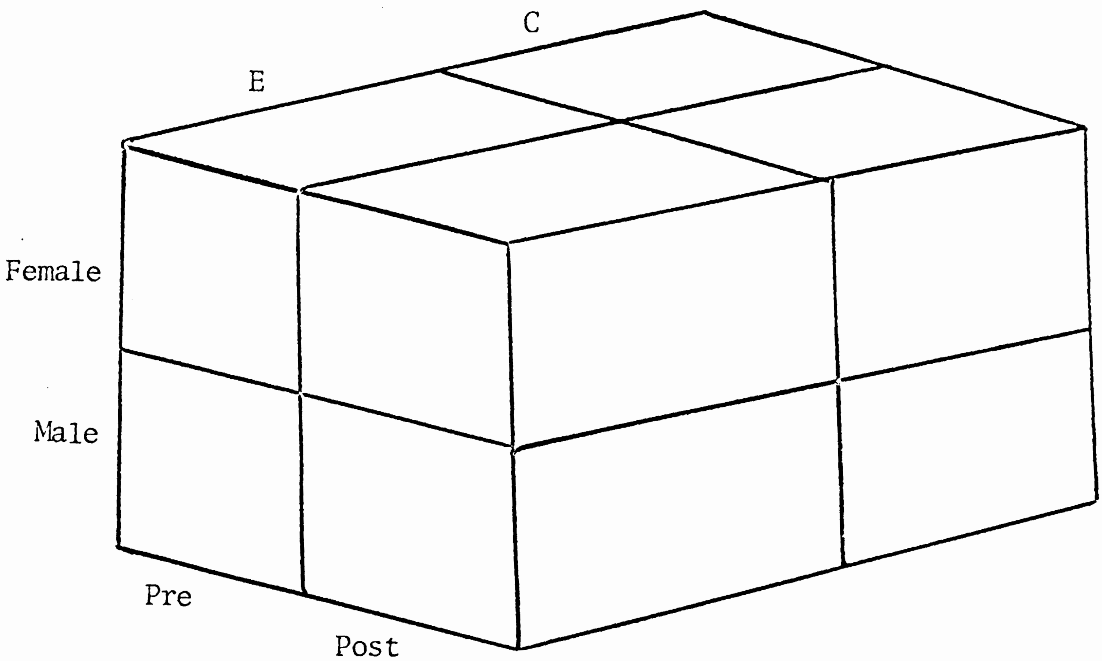
Data collection forms (see Appendix D) were prepared to record pertinent information for students participating in the experiment.

Names and sex of students were received from each teacher and transferred to the data collection forms. Results from the Science Research Associates Assessment Survey, Form E, mathematics section, were secured from the Norfolk and Portsmouth testing departments. This test was administered two days prior to the beginning of the study. These machine-scored data, a part of the group testing program of each school system, were used to serve as a pretest measure in the analysis of data collected for the study. Following the administration of the pretest, the activities as listed in the schedule were implemented. Weekly meetings were held with teachers for the purpose of monitoring and maintaining proper control of the experiment. Unlimited privileges were extended to the investigator by principals and teachers on an unannounced basis.

Posttests were administered by the teachers and assisted by the researcher at the end of the treatment period. The mathematics section, Form F of Science Research Associates Assessment Survey, the Attitude Toward Arithmetic Scale (see Appendix F) and The Piers/Harris Children's Self Concept Scale were given to both experimental and control groups.

TREATMENT OF DATA

A pictorial representation of the experimental design in measuring achievement is shown in Figure 2. The differences between pretest and posttest scores for students in the experimental and control groups and for females and males in mathematics achievement, mathematical



E - Experimental
C - Control

Figure 2

Experimental Design Utilized in Measuring Achievement computations and mathematical concepts were determined through the use of this design.

Data obtained on total mathematics achievement, computation and concepts for pretests and posttests, and posttests of attitude and self-concept were transferred to computer cards for multivariate analysis of covariance. Analysis of covariance is a form of analysis of variance that tests the significance of the difference between means of final experimental data by taking into account the correlation between the dependent variables and one or more covariates, and by adjusting initial mean differences in the experimental groups.[38] This statistical application controls variables somewhat as matching or random selection does. It was necessary to employ this treatment since the groups were investigated as intact classes.

The SRA scores, attitudinal scores and the self-concept scores were used as covariates in the multivariate analysis of covariance. The computer program, Multivariate Analysis of Variance, was chosen to compute the multivariate analysis of covariance.[39] A pictorial representation of the experimental design for measuring attitudes and self-concept is shown in Figure 3.

The null hypothesis was stated in Chapter 1. For purposes of analysis, a restatement of the null hypothesis and sub-hypotheses are included here.

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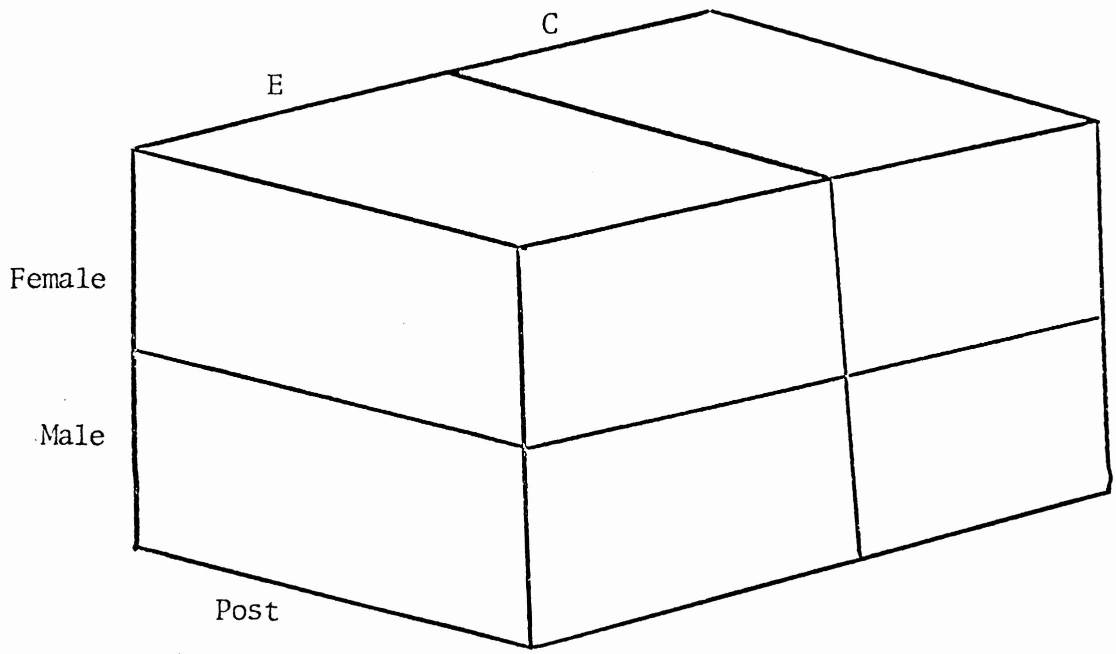
[38]Fred N. Kerlinger, Foundations of Behavioral Research (New York: Holt, Rinehart and Winston, Inc., 1973), p. 370.

[39]Multivariate Analysis of Variance (Florida: Clyde Computing Service, January, 1976).



E - Experimental
C - Control

Figure 3

Experimental Design Utilized
in Measuring Attitudes and Self Concept

Null Hypothesis

There is no difference in the mathematics achievement, attitude and self-concept of students using the hand-held calculator during the learning period and students performing without the use of the hand-held calculator as measured by pretest/posttest scores on the Science Research Associates Assessment Survey and posttest scores on the Attitude Toward Arithmetic Scale and The Piers/Harris Children's Self Concept Scale.

Sub-hypotheses

√ 1. There is no difference in the mathematics achievement of students using the calculator and students performing without the use of the calculator.

√ 2. There is no difference in the mathematics achievement between female and male students using the calculator and between female and male students performing without the use of the calculator.

3. There is no difference in the mathematics computation scores of students using the calculator and students performing without the use of the calculator.

4. There is no difference in the mathematics computation scores between female and male students using the calculator and between female and male students performing without the use of the calculator.

5. There is no difference in the mathematics concept scores of students using the calculator and students performing without the use of the calculator.

6. There is no difference in the mathematics concept scores between female and male students using the calculator and between female and male students performing without the use of the calculator.

7. There is no difference in the attitude of students using the calculator and students performing without the use of the calculator.

8. There is no difference in the attitudes between female and male students using the calculator and between female and male students performing without the use of the calculator.

9. There is no difference in the self-concept of students using the calculator and students performing without the use of the calculator.

10. There is no difference in the self-concept between female and male students using the calculator and between female and male students performing without the use of the calculator.

Chapter 4

ANALYSIS OF DATA

As indicated in Chapter 3, the purpose of this research project was to determine the effect of the hand-held calculator on the mathematics achievement, attitude and self-concept of sixth grade students. For this purpose, total mathematics achievement, concepts and computation scores of students using the calculator were compared with the total mathematics achievement, concepts and computation scores of students performing without the use of the calculator. A similar comparison of attitude and self-concept scores was made. Additionally, comparisons of achievement including concepts and computations, attitude and self-concept between female and male students in experimental and control groups were completed.

The sample for this investigation was six intact sixth grade classes composed of ninety-one female and eighty male students. No apparent learning disability in any of the students was in evidence.

Mathematics scores from the Science Research Associates Assessment Survey were obtained from each of the schools involved in the study. These data served as pretest data. Scores of the alternate form of the SRA test, the attitude test and the self-concept test were used as posttest data. The SRA pretest scores were used as covariates in the multivariate analyses of covariance. The multivariate analyses of variance allowed for the simultaneous evaluation of the significance of each of the factors involved. It further provided information required in determining the difference in effect of treatment on experimental and control groups. F tests were also used to determine the significance of the pretest, posttest differences for both treatment and sex when appropriate. A .05 level of confidence was used as the criterion for rejecting the null sub-hypotheses.

Sub-hypothesis one dealt with the effects of the treatment on the mathematics achievement of the experimental group when measured by the mathematics section of the Science Research Associates Assessment Survey. Pretest, posttest and adjusted posttest means for total mathematics scores of both the experimental and control groups are given in Table 1. These results indicated similar pretest means for both groups. However, the posttest and adjusted posttest means for the experimental group were higher than those for the control group. Further evidence of the effect of the treatment was produced when an F ratio of 50.91 with a probability of $< .001$ was given. From these data, sub-hypothesis one which stated there would be no difference in mathematics achievement of students using the calculator and those performing without the calculator was rejected.

A graphic representation of total mathematics achievement is shown in Figure 4.

Any difference produced between experimental female and male students in mathematics achievement was addressed in sub-hypothesis two. With the SRA pretest as the covariate and the SRA posttest as the criterion variable, an analysis of covariance for mathematics achievement was completed. The data from this analysis are presented

Table 1

Pretest, Posttest and Adjusted Posttest Mean Scores on Total Mathematics Achievement

	Pretest			Posttest			Adjusted Posttest	
	N	Mean	SD	N	Mean	SD	N	Mean
Experimental	113	32.57	12.75	113	37.74	11.30	113	37.75
Control	58	32.64	14.64	58	31.85	13.28	58	31.81

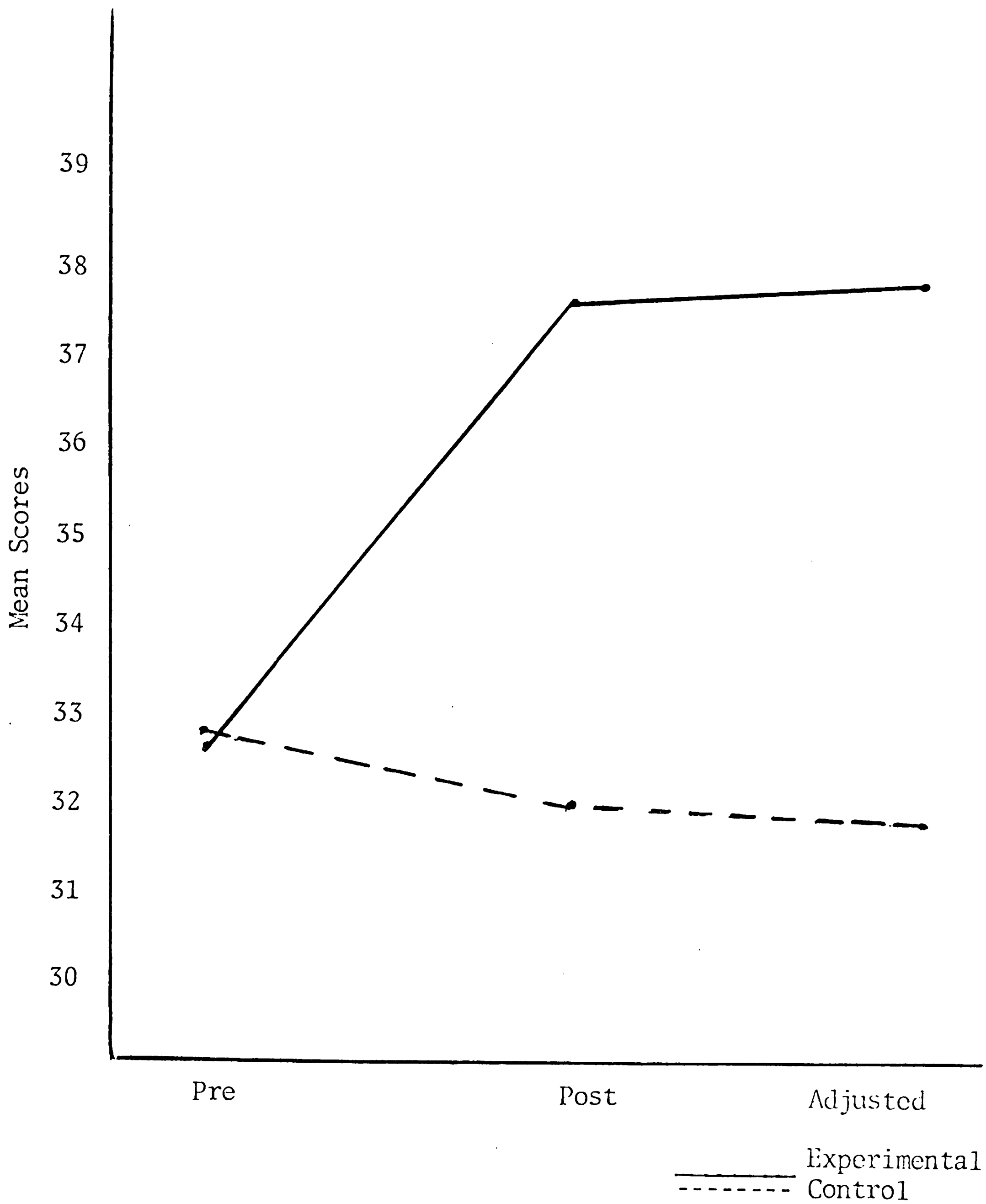


Figure 4

Pretest, Posttest and Adjusted Posttest Mean Scores on Total Mathematics Achievement in Table 2. An F ratio of 1.901 with a probability < 0.170 indicated no significant difference with respect to sex. Therefore, sub-hypothesis two which stated that no statistically significant difference would occur between female and male students performing with the calculator and those performing without the instrument was not rejected.

The specific question which sub-hypothesis three attempted to address was, "Are there differences in the mathematics computation scores of students using the calculator and students performing without the instrument?" Table 3 presents the pretest, posttest and adjusted posttest means of both the experimental and control groups on SRA pretests and posttests. Upon inspection, the means of the pretest, posttest and adjusted posttest scores for the control group were almost the same while there was a noticeable difference in the means of the pretest and the means of the posttest and adjusted scores for the experimental group. The adjusted mean for the experimental group was also greater than the adjusted mean for the control group. The difference in SRA pretests had been removed through the covariance analysis. Results from the multivariate analysis indicated that the posttest scores, adjusted for the covariate, did differ significantly between the experimental group and the control group ($F = 44.157$ and $P < .001$). Sub-hypothesis three was rejected on the basis of the evidence presented.

A graphic representation of computation mean scores is presented in Figure 5.

Table 2

Analysis of Covariance for Mathematics Achievement on SRA Test

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F Ratio	P
Sex	1.793	1	1.793	0.666	0.797
Treatment	1355.004	1	1355.004	50.091	0.001
Sex X Treatment	51.426	1	51.426	1.901	0.170
Within	4490.441	166	27.051		

Table 3

Pretest, Posttest and Adjusted Posttest Means on Computation

	Pretest			Posttest			Adjusted Posttest	
	N	Mean	SD	N	Mean	SD	N	Mean
Experimental	113	16.62	7.01	113	19.84	6.39	113	19.70
Control	58	15.86	7.77	58	15.33	8.29	58	15.60

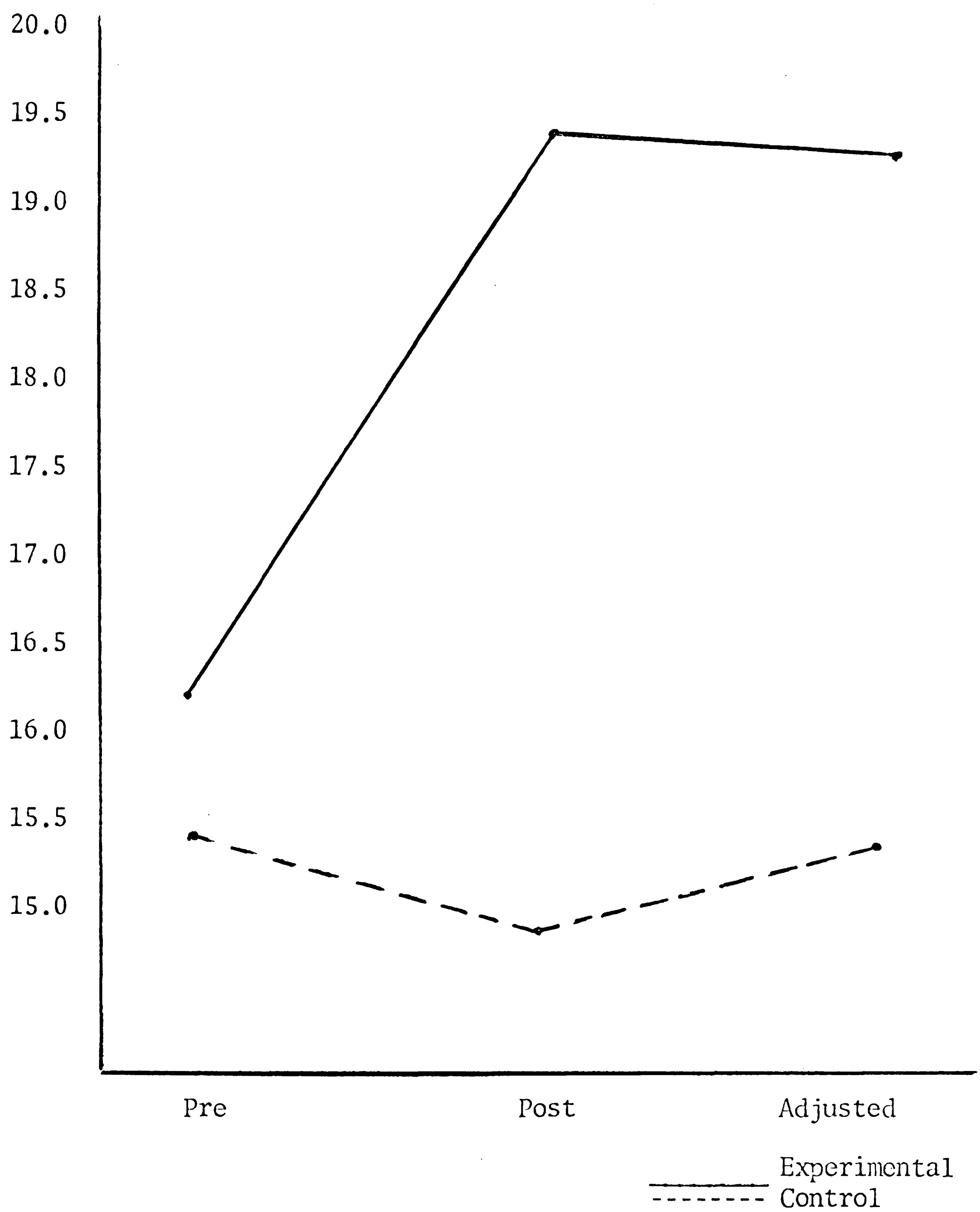


Figure 5

Pretest, Posttest and Adjusted Posttest Means on Computation

Sub-hypothesis four stated that there was no difference in the computation scores between female and male experimental and control students performing with the calculator and those performing without the device. Table 4 shows the pretest, posttest and adjusted posttest means in computation analyzed according to sex. Means for the control group for both sexes were almost the same while a noticeable difference was apparent in the means of both sexes in the experimental group. The adjusted posttest means for the experimental female group declined slightly while the adjusted posttest mean for the experimental male group increased slightly. The difference in SRA pretests for each group had been removed through the covariance analysis. Data from this statistical treatment showed an F ratio of 1.864 and a $P < 0.174$. This result did not indicate significance, therefore, sub-hypothesis four which indicated that there would be no difference in computation scores with respect to sex was not rejected.

The data referring to sub-hypothesis four are presented in graphic form in Figure 6.

Sub-hypothesis five stated that there would be no difference in the mathematics concept scores of students receiving treatment and those performing without treatment. Table 5 shows that the mean on the pretest for the experimental and control groups did not differ significantly, however, posttest scores revealed a greater difference between the two groups. Adjusted means on the pretest resulted in higher scores for the experimental group than for the control group. This difference, $F = 9.614$ and $P < .002$ as determined by the multivariate

Table 4

Pretest, Posttest and Adjusted Posttest Means on Computation for Female and Male Students

		Pretest			Posttest			Adjusted Posttest	
		N	Mean	SD	N	Mean	SD	N	Mean
Experimental	Female	58	17.14	6.63	58	20.17	6.13	58	19.54
	Male	55	16.07	7.41	55	19.49	6.69	55	19.87
Control	Female	33	16.88	7.80	33	16.70	8.13	33	16.19
	Male	25	14.52	7.68	25	15.32	8.32	25	14.82

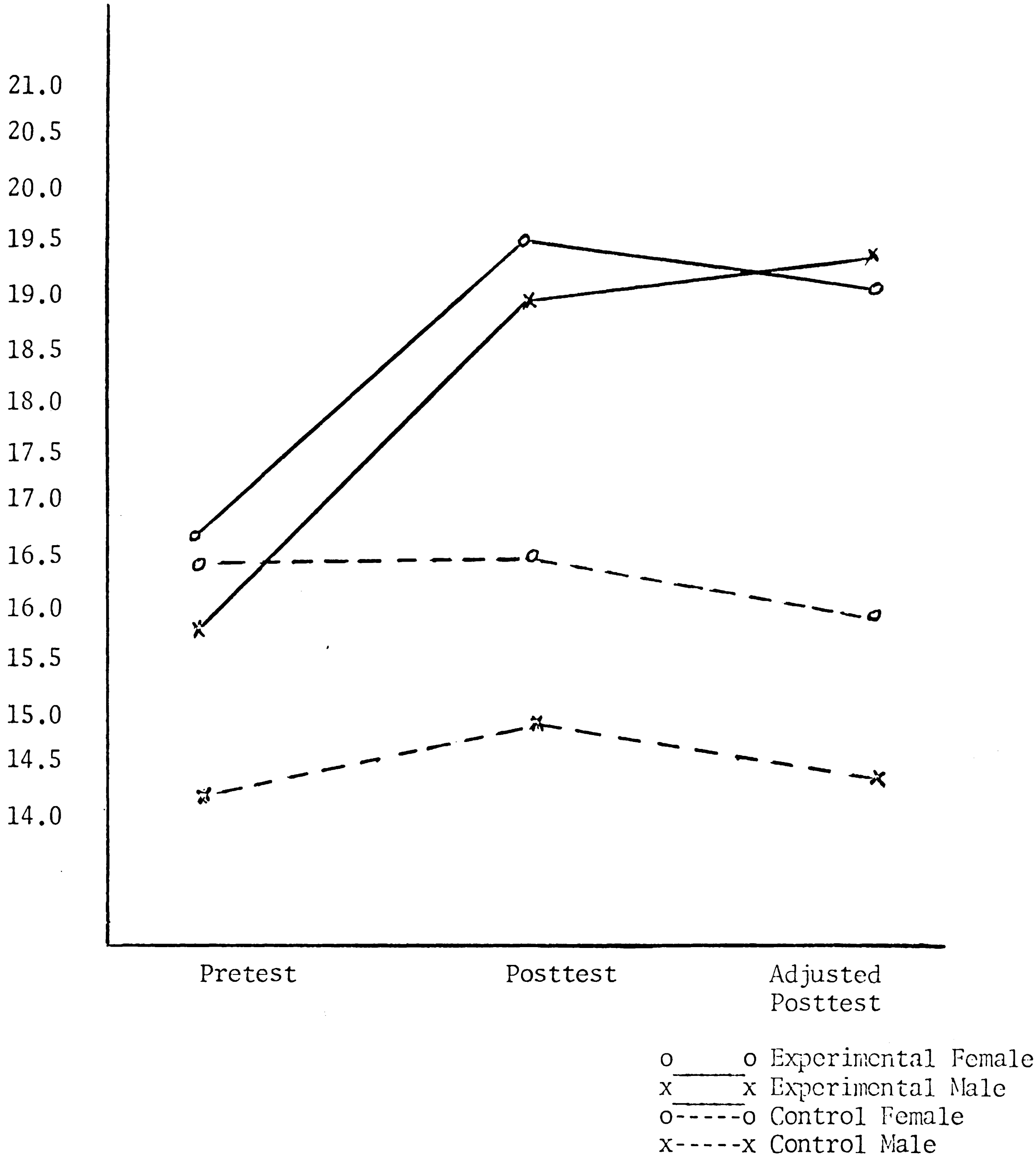


Figure 6

Pretest, Posttest and Adjusted Posttest Means on Computation for Female and Male Students

Table 5

Pretest, Posttest and Adjusted Posttest Means on Concepts

	Pretest			Posttest			Adjusted Posttest	
	N	Mean	SD	N	Mean	SD	N	Mean
Experimental	113	16.03	6.67	113	17.99	5.79	113	18.09
Control	58	16.78	8.24	58	16.57	6.92	58	16.37

tests of significance, was significant. This sub-hypothesis which stated that there was no difference in the concept scores of the two groups, experimental and control, was rejected.

Data on sub-hypothesis five ragarding mathematics scores are shown graphically in Figure 7.

To answer the question, "Are there differences in concept scores between female and male students after treatment?", which is also stated in the null form in sub-hypothesis six, a multivariate test of significance was computed. Table 6 shows the pretest, posttest and adjusted posttest means on concept scores of both experimental and control groups analyzed according to sex. Means for both sexes in experimental and control groups fluctuated. However, results from the multivariate analysis showed an F ratio of 1.864 and a $P < .001$. These data indicated a significant difference in the concept scores between female and male students after treatment, therefore, the sub-hypothesis stating that there would be no difference in the concept scores between female and male students after treatment was rejected.

A graphic representation of the data for this sub-hypothesis is presented in Figure 8.

Sub-hypothesis seven was concerned with whether treatment caused a difference in attitude between experimental and control students. SRA pretest and attitude posttest scores were subjected to a multivariate test of significance. Results indicated no significant difference between the experimental and control groups (F = 0.079,

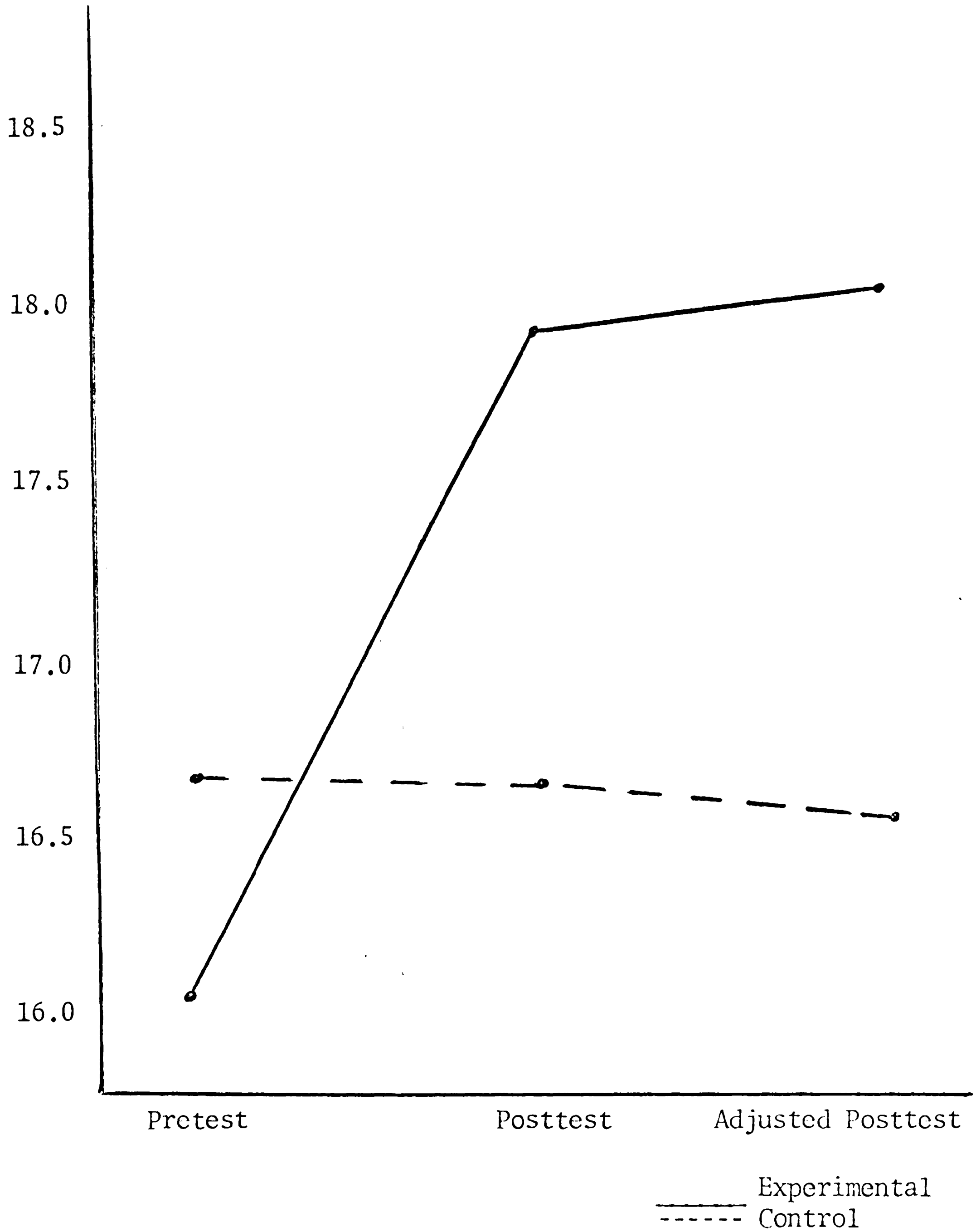


Figure 7

Pretest, Posttest and Adjusted Posttest Means on Concepts

Table 6

Pretest, Posttest and Adjusted Posttest Means on Concepts for Female and Male Students

		Pretest			Posttest			Adjusted Posttest	
		N	Mean	SD	N	Mean	SD	N	Mean
Experimental	Female	58	16.81	6.62	58	19.10	5.78	58	18.66
	Male	55	15.20	6.68	55	16.82	5.62	55	17.49
Control	Female	33	17.18	8.23	33	15.76	6.31	33	15.15
	Male	25	16.24	8.38	25	17.64	7.65	25	17.99

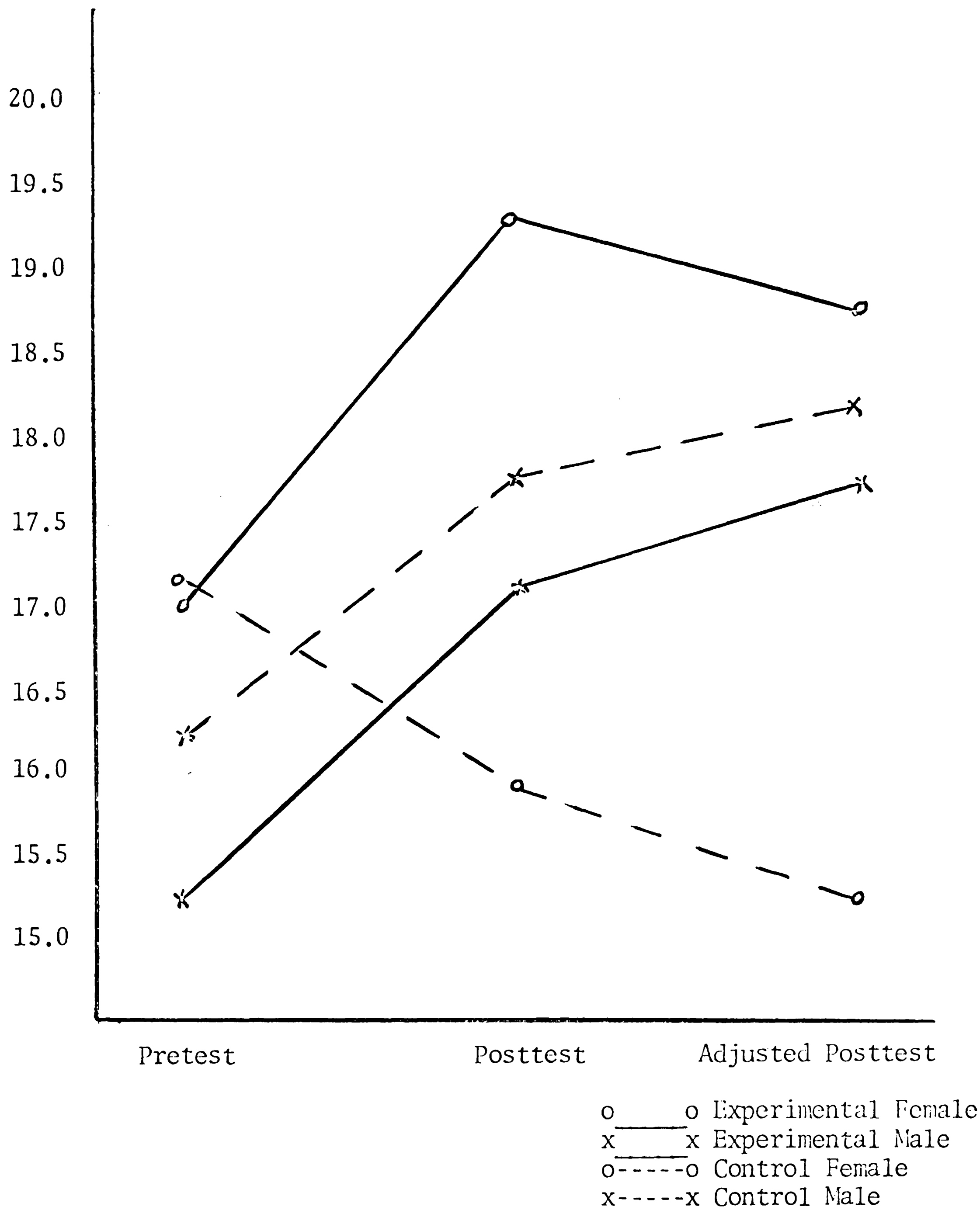


Figure 8

Pretest, Posttest and Adjusted Posttest Means on Concepts for Female and Male Students

$P < 0.779$). Based upon these results, sub-hypothesis seven which stated there would be no difference in attitude between experimental and control students was not rejected.

Further investigation of the effects of the treatment on attitude using sex as a factor was completed to substantiate sub-hypothesis eight. Using the SRA pretest and the attitude posttest, a multivariate analysis was used to determine significance. An F ratio of 0.037 and a $P < 0.847$ indicated that sex was not a controlling factor, therefore, sub-hypothesis eight was not rejected.

Sub-hypothesis nine dealt with the effect of treatment on the self-concept of experimental students as compared to control students. The covariate (SRA pretest) and self-concept scores were subjected to a multivariate test of significance. An F ratio of 0.921 with a $P < 0.339$ indicated no statistically significant difference between experimental and control groups. The sub-hypothesis stating that there would be no difference in the self-concept of students using the calculator and students performing without the instrument was not rejected.

Finally, sub-hypothesis ten was concerned with whether sex was a controlling factor with respect to treatment and non-treatment regarding self-concept. The SRA pretest and self-concept scores were subjected to a multivariate analysis of variance test. Results revealed an F ratio of 0.200 and a $P < 0.655$. These data did not provide sufficient evidence to reject the sub-hypothesis that there is no difference in the self-concept scores between female and male students using the calculator and between female and male students performing without the use of the calculator.

Though no differences in the self-concept scores of experimental and control students were found, novel experiences such as these are beneficial for students.

Student responses to five questions that could not be computer analyzed are reported in Tables 7 and 8. Question sixteen in Table 7 was designed to determine how students felt about mathematics. The mean score for the female experimental group was lower than the mean score for the male experimental group. The opposite was true for the control group. An effort to determine in which grades these feelings were developed was made by asking question seventeen. Results indicated that feelings were formed during the fourth grade by the experimental group and during the third grade for the control group. Results from question eighteen revealed that both groups of students averaged grades of "B-". No evidence was found to suggest that treatment had any effect on student feelings regarding mathematics.

Table 8 showed things liked and disliked by experimental female and male students and by control female and male students. Among the top three choices for each group were addition, multiplication and division. Fourth choice among male control students was word problems while male experimental students chose calculators. Fourth choice among female experimental students was word problems while female control students liked fractions.

Among things disliked by experimental female students, fractions ranked highest. Male experimental students tended to dislike division

Table 7

Results of Questions on Attitude Test

	Experimental				Control			
		Mean				Mean		
	N	Female	N	Male	N	Female	N	Male
16. How you feel about arithmetic	58	7.97	55	8.04	33	8.21	26	7.58
17. Feelings toward arithmetic developed in grades	58	4.05	55	4.18	33	3.58	26	3.85
18. Average grades made in arithmetic	58	2.84	55	2.58	33	3.06	26	2.35

Table 8

Results of Questions on Attitudinal Test

Statement	Experimental % (N=79) Female	Male	Control % (N=28) Female	Male
19. Things liked about arithmetic				
Games	4			
Word Problems	14	9	4	14
Division	19	12	11	18
Decimals	11	16	11	4
Fractions	5	3	13	4
Measurement	1	1		
Multiplication	14	9	27	29
Subtraction	6	9	11	
Puzzles		1		
Addition	23	19	24	32
Calculators	1	15		
Metric System	1	3		
Geometry		1		

Table 8 (Continued)

	Experimental		Control	
	Female % (N=40)	Male % (N=48)	Female % (N=38)	Male % (N=19)
20. Things disliked about arithmetic				
Geometry	8	4		11
Time	2			
Area	5		3	
Volume	2		3	
Multiplication	10	15	18	5
Subtraction	8	2	21	16
Metric System	8	19	3	11
Division	10	19	21	16
Fractions	23	17	16	37
Percentage	2			
Measurement	8	6		
Word Problems	5	13	3	
Perimeter	2	4		
Addition	2		7	5
Decimals	5	2	3	
Roman Numerals			3	

and the metric system. Female control students disliked subtraction and division while male control students disliked fractions.

At the end of the research project, students in the control group were asked if they had used calculators at home during the experiment. Ten students who responded positively were dropped from the sample and separate multivariate analyses of covariance were used to determine if significant differences existed between experimental and control groups. No differences were found to be in evidence without these ten students.

The potential of the Hawthorne Effect was considered in this research effort but was discarded when it was deemed inappropriate. In the normal elementary environment, students are subjected to novel situations and technology that approach experimental conditions; consequently, there is no difference between the research effort and the everyday world of students.

Summary

The purpose of this research was to determine the effects of the hand-held calculator on the mathematics achievement, attitude and self-concept of sixth-grade students. The null hypothesis stated that there is no difference in the mathematics achievement, attitude and self-concept of students using the hand-held calculator during the learning period and students performing without the use of the hand-held calculator as measured by pretest/posttest scores on the Science Research Associates Assessment Survey, and posttest scores on the Attitude Toward Arithmetic Scale and the Piers-Harris Children's Self

Concept Scale. Sub-hypotheses one, three and five were those associated with achievement in mathematics of the experimental and control groups. The experimental group showed significant improvement over the control group in mathematics achievement, computation and concepts during the learning period. Sub-hypotheses two, four and six were those associated with sex differences in relation to mathematics achievement, computation and concept scores. Sex was not a contributing factor except with concept scores where the experimental females were favored. Those sub-hypotheses concerned with attitude and self-concept scores were seven and nine while eight and ten were concerned with attitude and self-concept using sex as a factor. Sub-hypothesis one which related directly to mathematics achievement, sub-hypothesis three which related to achievement in computation and sub-hypothesis five which related to concept achievement were rejected. Sub-hypothesis six which dealt with concept achievement associated with sex differences was also rejected. All other sub-hypotheses were not rejected.

At the end of the study, control students were asked if they had used calculators during the course of the experiment. Ten students responded positively; therefore, a reanalysis of the sample was completed without these students. This treatment did not reveal any different results than those which included the ten students.

Among those things liked about mathematics which were most pertinent to this investigation were calculators chosen by male experimental students. All other data regarding this area revealed no significant findings.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

This study was designed to investigate the effects of the hand-held calculator on the mathematics achievement, attitude and self-concept of sixth grade students. It further attempted to compare achievement, attitude and self-concept between female and male students using the calculators with those performing without the calculator. Those students utilizing the calculators were referred to as experimental students and those who used pencil and paper only were referred to as control students. The experiment involved 113 experimental students and 58 control students. Six intact classes were assigned randomly to treatment.

Limitations placed on the study were (1) three sixth grade classes in the Norfolk Public Schools and three sixth grade classes in the Portsmouth City Schools and (2) a nine week duration during the Fall of 1975.

Teachers of experimental and control students used identical learning objectives and each followed a prepared schedule. The instructional periods were held for 55-60 minutes daily for a total of nine weeks. Treatment started in October and ended in December with the administration of an SRA posttest in mathematics which included concepts and computation, an attitudinal test and a self-concept test. Students were not permitted to use calculators during test periods. This was done to make comparable testing situations for experimental and control groups. The mathematics section of the SRA was used as the covariate in multivariate analyses of covariance.

Findings of this research under the limitations of the study indicated the following:

1. Significant improvement in the mathematics achievement of experimental students.

2. No difference in the mathematics achievement between female and male experimental students and between female and male control students.

3. Significant improvement in the computation scores of experimental students.

4. No difference in the computation scores between female and male experimental students and between female and male control students.

5. Significant improvement in the concept scores of experimental students.

6. Significant improvement in the concept scores between experimental female and male students.

7. No difference in attitude between experimental and control students.

8. No difference in attitude between female and male experimental students and between female and male control students.

9. No difference in self-concept between experimental and control students.

10. No difference in self-concept between female and male experimental students and between female and male control students.

CONCLUSIONS

These findings indicated that significant improvement in mathematics achievement, including concepts and computation, did occur during the learning period of this investigation; moreover, sex was not a contributing factor except with concepts scores. No improvement or change was found with respect to attitude or self-concept. These findings give further support to previous research which indicated the hand-held calculator could be used as a tool to (1) discover new ways of utilizing the instrument, (2) reduce boring, tedious drill and (3) serve as a motivational instrument. One of the most important uses this investigator gleaned from the experiment was that the hand-held calculator could be used to personalize instruction.

RECOMMENDATIONS

Since there were significant differences between the experimental and the control group in favor of the experimental group, it might be assumed that the use of the hand-held calculator is effective in improving mathematics achievement. However, further research is needed before making major decisions relative to complete usage of the hand-held calculator. Some general recommendations for additional studies are presented below:

1. Since the student population was restricted to intact class groups, it is recommended that similar studies be made using a wider population sample at other grade levels.

2. In view of the fact that significant differences in mathematics achievement were found to exist between the experimental and control groups, it is recommended that a similar study involving slow students be made to determine the effectiveness of the hand-held calculator with this group.

3. In view of the fact that significant differences in mathematics achievement were found to exist between the experimental and control groups, it is recommended that a similar study involving low income, primary students be made to determine the effectiveness of the hand-held calculator with this group.

4. In light of the positive findings in this study with respect to mathematics achievement, it is recommended that a cost analysis study be conducted to determine feasibility of incorporating use of the hand-held calculator in classrooms on a permanent basis.

5. In light of the fact that significant differences in computation scores were found to exist between experimental and control groups, it is recommended that a similar study be conducted to determine if students maintain computation skills.

6. In view of the fact that significant differences in concept scores were found to exist between female and male students, it is recommended that further research be conducted to determine whether use of the calculator will continue to produce this difference.

7. It is further recommended that mathematics educators develop new instruments for measuring effectiveness of newer technologically produced instructional aids.

BIBLIOGRAPHY

Articles, Periodicals and Books

Advant, Kan. "The Effect of the Use of Desk Calculators on Achievement and Attitude of Children with Learning and Behavior Problems." Paper presented at the Fourteenth Annual Conference of the Ontario Educational Research Council, December, 1972.

Aiken, Lewis R., Jr. "Two Scales of Attitude Toward Mathematics," Journal for Research in Mathematics Education, V (March, 1974), 356-358.

________. "Research in Attitudes Toward Mathematics," The Arithmetic Teacher, XIX (March, 1972), 229-231.

Anastasia, Anne. Differential Psychology. New York: The Macmillan Company, 1969.

Beck, Lois L. "A Report on the Use of Calculators," The Arithmetic Teacher, VII, 2 (February, 1960), 103.

Campbell, Donald T., and Julian C. Stanley. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally and Company, 1963.

Capps, Lelon R., and Linda Simon Cox. "Attitude Toward Arithmetic at the Fourth and Fifth Grade Levels," The Arithmetic Teacher, XVI, 3 (March, 1969), 215-220.

Cech, Joseph Phillip. "The Effect of the Use of Desk Calculators on Attitude and Achievement with Low-Achieving Ninth Graders," The Mathematics Teacher, LXV, 2 (February, 1972), 183-186.

Corcoran, Mary, and E. Glenadine Gibb. "Appraising Attitudes in the Learning of Mathematics," Evaluation in Mathematics, Twenty-sixth Yearbook of the National Council of Teachers of Mathematics, 1965.

Denman, Thelma. "Calculators in Class," Instructor, LXXXIII (February, 1974), 56-57.

Dutton, Wilbur H., and Martha Perkins Blum. "The Measurement of Attitudes Toward Arithmetic With A Likert-Type Test," Elementary School Journal, 68 (February, 1968), 259-264.

Ellis, June, and Al Corum. Functions of the Calculator in the Mathematics Laboratory for Low Achievers. U. S. Educational Resources Information Center, ERIC Document ED 040 847, 1969.

Etlinger, Leonard. "The Electronic Calculator: A New Trend in School Mathematics," Educational Technology, XIV (December, 1974), 44.

Feder, Chris Welles. "Children and Calculators: Do They Add Up?" McCall's Magazine, May, 1975, 34.

Fellows, Martha M. "A Mathematics Attitudinal Device," The Arithmetic Teacher, XX (March, 1973), 222-223.

Fennema, Elizabeth. "Manipulatives in the Classroom," The Arithmetic Teacher, XX (May, 1973), 350-352.

Gaslin, William L. "A Comparison of Achievement and Attitudes of Students Using Conventional or Calculator Based Algorithms for Operations on Positive Rational Numbers in Ninth Grade General Mathematics." Paper presented at the annual meeting of the American Educational Research Association, April, 1974, Chicago, Illinois.

Grosswirth, Marvin. "Calculators in the Classroom." Datamation, XXI (March, 1975), 90-95.

Hawthorne, Frank S. "Hand-held Calculators: Help or Hindrance?" The Arithmetic Teacher, XX (December, 1973), 671-672.

Higgins, Jon L. "Mathematics Programs are Changing," The Education Digest, XL (December, 1974), 56-58.

Keough, John J., and Gerald W. Burke. Utilizing an Electronic Calculator to Facilitate Instruction in Mathematics in the 11th and 12th Grades. U. S. Educational Resources Information Center, ERIC Document ED 037 345, July, 1969.

Kerlinger, Fred N. Foundations of Behavioral Research. New York: Holt, Rinehart and Winston, Inc., 1973.

Knaupp, Jonathan. "Are Children's Attitudes Toward Learning Arithmetic Really Important?" School Science and Mathematics, LXXIII (January, 1973), 9-15.

Kuhfittig, Peter K. F. "Learning Aids in the Classroom: Experimental Evidence of Their Effectiveness," Education, XCIV (November/December, 1973), 135-136.

________. "The Relative Effectiveness of Concrete Aids in Discovery Learning," School Science and Mathematics, LXXIV (February, 1974), 104-108.

Larson, J. P. "Azimuth: New Math Tool," Pennsylvania School Journal, CXXI (April, 1973), 188-190.

Leake, Lowell, Jr. "Calculators in the Classroom," The Mathematics Teacher, III (March, 1975), 226.

Lewis, Philip. "Mini-Calculators Have Maxi-Impact," Nation's Schools and Colleges, XCII (May, 1974), 61-62.

Longstaff, F. R., R. Stevens, and A. J. King. "Desk Calculators in the Mathematics Classroom. Paper presented at the Canadian Conference on Education Research, June, 1968.

Monroe, The Calculator Company. Operating Instructions, Model 30, Portable Electronic Display Calculator. Orange, New Jersey: Litton Business Systems, Inc., 1974.

Naslund, Robert A., Louis P. Thorpe and D. Welty Lefever. Test Coordinator's Handbook-Achievement Series. Chicago: Science Research Associates, 1975.

Piers, Elen V. Manual for the Piers-Harris Children's Self Concept Scale. Nashville: Counselor Recordings and Test, 1969.

Reys, Robert E. "Considerations for Teachers Using Manipulative Materials," The Arithmetic Teacher, XVIII (December, 1971).

Schart, Eugenia S. "The Use of the Semantic Differential in Measuring Attitude of Elementary School Children Toward Mathematics," School Science and Mathematics, LXXI (October, 1971), 641-649.

Skoll, Pearl A. The Mobile Computer Mathematics Laboratory. ESEA III, Los Angeles Unified School District, 1971-1974.

Sosebee, Jackson B., Jr., and Lola Mae Walsh. "Pocket Calculators and Test Scores in Introductory Chemistry," Journal of College Science Teachings, IV (May, 1975).

Suydam, Marilyn N. "A Categorized Listing of Research on Mathematics Education (K-12) 1964-1973." Center for Science, Mathematics and Environmental Education, Ohio State University, 1974.

The Great Calculator Debate. Nation's Schools and Colleges, I (December, 1974), 12-14.

"Using Hand-held Calculators in Sixth Grade Classes." A Brief Report of an Educational Project. The State Education Department, The University of the State of New York, September, 1973.

Wozencraft, Marian. "Correlation Among Stanford Achievement Test Scores, Intelligence and Age in Grades 3 and 6," Psychological Reports, XXXIII (August, 1973).

"1984: A Calculator on Every Wrist and in Every School Desk, Too," Nation's Schools and Colleges, I (December, 1974), 13.

Unpublished and Miscellaneous Materials

Ashby, Willie Ross. "The Slide Rule: Its Effect Upon Interest, Computation and Reasoning Among Seventh Grade Mathematics Students." Unpublished Doctor's dissertation, Texas State University, 1974.

Carmody, Lenora M. "A Theoretical and Experimental Investigation into the Role of Concrete and Semi-Concrete Materials in the Teaching of Elementary School Mathematics." Unpublished Doctor's dissertation, Ohio State University, 1970.

Durrance, Victor R. "The Effect of the Rotary Calculator on Arithmetic Achievement in Grades Six, Seven and Eight." Unpublished Doctor's dissertation, George Peabody College for Teachers, 1964.

Eudy, Elaine Holland. "The Effectiveness of a Mathematical Device Called a Tryab on the Arithmetic Achievement of Primary Students." Unpublished Doctor's dissertation, The University of Mississippi, 1973.

Fennema, Elizabeth H. "A Study of the Relative Effectiveness of a Meaningful Concrete and a Meaningful Symbolic Model in Learning a Selected Mathematical Principle." Unpublished Doctor's dissertation, The University of Wisconsin, 1969.

Johnson, Robert L., Jr. "Effects of Varying Concrete Activities on Achievement of Objectives of Perimeter, Area and Volume by Students of Grades Four, Five and Six." Unpublished Doctor's dissertation, University of Colorado, 1970.

Ladd, Norman Elmer. "The Effects of Electric Calculators on Attitude and Achievement of Ninth Grade Low Achievers in Mathematics." Unpublished Doctor's dissertation, Southern Illinois University, 1973.

Mandelbaum, Joseph. "A Study of the Effects on Achievement and Attitude of the Use of the Computer as a Problem Solving Tool with Low Performing Tenth Grade Students." Unpublished Doctor's dissertation, Temple University, 1973.

Mastbaum, Sol. "A Study of the Relative Effectiveness of Electric Calculators on Computational Skill Kits in the Teaching of Mathematics." Unpublished Doctor's dissertation, University of Minnesota, 1969.

Multivariate Analysis of Variance. Miami, Florida: Clyde Computing Service, January, 1976.

Nowak, Betty Adams. "A Study to Compare the Effects of Mathematics Laboratory Experiences on Intermediate Grade Students on Achievement and Attitude." Unpublished Doctor's dissertation, Brigham Young University, 1972.

Purser, Jerry Donaldson. "The Relation of Manipulative Activities, Achievement and Retention in a Seventh Grade Mathematics Class: An Exploratory Study." Unpublished Doctor's dissertation, University of Georgia, 1973.

Rich, Littleton Waldo. "The Effects of a Manipulative Instructional Mode in Teaching Mathematics to Selected 7th Grade Inner-City Students." Unpublished Doctor's dissertation, Temple University, 1972.

Roderick, Stephen Alan. "A Comparative Study of Mathematics Achievement by Sixth Graders and Eighth Graders, 1936 to 1973, 1951-55 to 1973, and 1965 to 1973." Unpublished Doctor's dissertation, University of Iowa, 1973.

Ronan, Franklin D. "Study of the Effectiveness of a Computer When Used as a Teaching and Learning Tool in High School Mathematics." Unpublished Doctor's dissertation, University of Michigan, 1971.

Shea, James Francis. "The Effects in Achievement and Attitude Among Fourth Grade Students Using Calculator Flow-Charting Instruction vs. Conventional Instruction in Arithmetic." Unpublished Doctor's dissertation, New York University, 1973.

Smith, Emma Drucilla. "The Effects of Laboratory Instruction Upon Achievement in and Attitude Toward Mathematics of Middle School Students." Unpublished Doctor's dissertation, Indiana University, 1973.

Spencer, Jo Ann Nora. "Using the Hand-held Calculator in Intermediate Grade Arithmetic Instruction." Unpublished Doctor's dissertation, Lehigh University, 1974.

Stocks, Sister Tina Marie. "The Development of an Instructional System Which Incorporates the Use of an Electric Desk Calculator as an Aid to Teaching the Concept of Long Division to Educable Mentally Retarded Adolescents." Unpublished Doctor's dissertation, Columbia University, 1972.

Walters, G. Hugh. "The Effects of an Individualized Laboratory Approach on the Teaching of Mathematics to Third Grade Students Achieving Below Grade Level." Unpublished Doctor's dissertation, Virginia Polytechnic Institute and State University, 1974.

APPENDIX A

Letters of Permission

Norfolk City Schools

ADMINISTRATION BUILDING, 800 EAST CITY HALL AVENUE
NORFOLK, VIRGINIA 23510

August 8, 1975

TO WHOM IT MAY CONCERN

This is to certify that approval has been given for Edris W. Jones and Maxine Allen to conduct an experimental study using the hand-held calculator at one of the elementary schools in the Norfolk Public Schools during the 1975-76 school year.

Norman D. Holthouse, Ph. D.
Director
Division of Research and Planning

PORTSMOUTH PUBLIC SCHOOLS
DEPARTMENT OF SECONDARY EDUCATION
Grand and Shelby Streets
Portsmouth, Virginia 23701

January 13, 1976

To Whom It May Concern:

This is to certify that approval has been given for Maxine Allen and Edris Jones to conduct an experimental study using hand-held calculators at one of the elementary schools in the Portsmouth Public School System during the 1975-76 school year.

Sincerely,

(Mrs.) Ann M. White
Mathematics Specialist

AMW/jb

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DEPARTMENT OF EDUCATION
LOS ANGELES, CALIFORNIA 90024

12 Sept. 1975

Edris W. Jones
1028 Dulcie Ave.
Virginia Beach, Virginia 23455

Dear Mrs. Jones:

Of course you may use my attitude scale in your study. I am sending the scale and a set of directions for administering. The scale values should not be printed on the form used. You may duplicate the scale. I do have copies at one cent each plus postage. But this may take longer than you wish.

Give me credit in a footnote and in your bibliography. Also send me a check for $1.00 to cover expenses in my office.

Best wishes to you in your important study.

Cordially,

Wilbur H. Dutton

APPENDIX B

Schedule for the Experiment

SCHEDULE FOR THE EXPERIMENT

Day 1	Teacher Orientation
Day 2	All Students - SRA
Day 3	All Students - Pretests, decimal test and The Criterion Referenced Test in Metrics Measurement
Day 4	Experimental Group - Instruction, Use of the Calculator Control Group - Lesson 1 (See Learning Objectives)
Day 5	Experimental Group - Lesson 1 Control Group - Lesson 2
Day 6	Experimental Group - Lesson 2 Control Group - Lesson 3
Day 7	Experimental Group - Lesson 3 Control Group - Lesson 4
Day 8	Experimental Group - Lesson 4 Control Group - Lesson 5
Day 9	Experimental Group - Lesson 5 Control Group - Lesson 6
Day 10	Experimental Group - Lesson 6 Control Group - Lesson 7
Day 11	Experimental Group - Lesson 7 Control Group - Lesson 8
Day 12	Experimental Group - Lesson 8 Control Group - Lesson 9
Day 13	Experimental Group - Lesson 9 Control Group - Lesson 10
Day 14	Experimental Group - Lesson 10 Control Group - Lesson 11
Day 15	Experimental Group - Lesson 11 Control Group - Lesson 12
Day 16	Experimental Group - Lesson 12 Control Group - Lesson 13

Day 17 Experimental Group - Lesson 13
Control Group - Lesson 14

Day 18 Experimental Group - Lesson 14
Control Group - Lesson 15

Day 19 Experimental Group - Lesson 15
Control Group - Lesson 16

Day 20 Experimental Group - Lesson 16
Control Group - Lesson 17

Day 21 Experimental Group - Lesson 17
Control Group - Lesson 18

Day 22 Experimental Group - Lesson 18
Control Group - Lesson 19

Day 23 Experimental Group - Lesson 19
Control Group - Lesson 20

Day 24 Experimental Group - Lesson 20
Control Group - Lesson 21

Day 25 Experimental Group - Lesson 21
Control Group - Lesson 22

Day 26 Experimental Group - Lesson 22
Control Group - Lesson 23

Day 27 Experimental Group - Lesson 23
Control Group - Lesson 24

Day 28 Experimental Group - Lesson 24
Control Group - Lesson 25

Day 29 Experimental Group - Lesson 25
Control Group - Posttests, decimal test and metric test

Day 30 Experimental Group - Posttests, decimal test and metric test
Control Group - Lesson 26

Day 31 Experimental Group - Lesson 26
Control Group - Lesson 27

Day 32 Experimental Group - Lesson 27
Control Group - Lesson 28

Day 33 Experimental Group - Lesson 28
Control Group - Lesson 29

Day 34 <u>Experimental Group</u> - Lesson 29
<u>Control Group</u> - Lesson 30

Day 35 <u>Experimental Group</u> - Lesson 30
<u>Control Group</u> - Lesson 31

Day 36 <u>Experimental Group</u> - Lesson 31
<u>Control Group</u> - Lesson 32

Day 37 <u>Experimental Group</u> - Lesson 32
<u>Control Group</u> - Lesson 33

Day 38 <u>Experimental Group</u> - Lesson 33
<u>Control Group</u> - Lesson 34

Day 39 <u>Experimental Group</u> - Lesson 34
<u>Control Group</u> - Lesson 35

Day 40 <u>Experimental Group</u> - Lesson 35
<u>Control Group</u> - Lesson 36

Day 41 <u>Experimental Group</u> - Lesson 36
<u>Control Group</u> - Lesson 37

Day 42 <u>Experimental Group</u> - Lesson 37
<u>Control Group</u> - Lesson 38

Day 43 <u>Experimental Group</u> - Lesson 38
<u>Control Group</u> - Lesson 39

Day 44 <u>Experimental Group</u> - Lesson 39
<u>Control Group</u> - Lesson 40

Day 45 <u>Experimental Group</u> - Lesson 40
<u>Control Group</u> - SRA - Piers-Harris Attitudinal

Day 46 <u>Experimental Group</u> - SRA - Piers-Harris Attitudinal

APPENDIX C

Learning Objectives

LEARNING OBJECTIVES

Lesson 1

1. The student will be able to use decimal notation for tenths, hundredths, thousandths, and ten-thousandths.
2. The student will be able to read decimals with at most four digits to the right of the decimal point.
3. The student will be able to tell which number in decimal form is the greater when two numbers have at most four digits to the right of the decimal point.

Lesson 2

4. The student will be able to add decimal numbers.

Lesson 3

5. The student will be able to subtract a decimal number from a decimal number.

Lesson 4

6. The student will be able to solve simple verbal problems involving addition or subtraction of decimal numbers.

Lesson 5

7. The student will be able to multiply any number in decimal form by a one-digit whole number.
8. The student will be able to multiply any number in decimal form by 10 and by 100.

Lesson 6

9. The student will be able to multiply any decimal number by a two-digit multiple of 10 and by a three-digit multiple of 100.

10. The student will be able to multiply a decimal number by a two-digit or three-digit whole number.

Lesson 7

11. The student will be able to divide a decimal number by a one-digit whole number.

12. The student will be able to divide a decimal number by a two-digit or three-digit whole number.

Lesson 8

13. The student will be able to compute average.

14. The student will be able to solve word problems about averages.

Lesson 9

15. The student will be able to solve word problems involving multiplication or division of decimals by whole numbers.

Lesson 10

16. The student will be able to tell whether a given quantity relates to length, area, or volume using metric units.

17. The student will be able to measure various lengths correct to the nearest millimeter.

Lesson 11

18. The student will be able to make conversions among metric units for measuring length.

Lesson 12

19. The student will be able to express one metric unit in terms of another, using decimals.

Lesson 13

20. The student will be able to compute, in metric units, perimeters of polygons.

Lesson 14

21. The student will be able to compute, in metric units, areas of parallelograms and triangles.

Lesson 15

22. The student will be able to compute, in metric units, the volume of solid figures composed of rectangular solids.

Lesson 16

23. The student will be able to solve word problems involving applications of length, area, or volume in the metric system.

Lesson 17

24. The student will be able to make conversions among metric units for measuring liquid volume and for measuring weight.

<u>Lesson 18</u>

25. The student will be able to multiply a number in decimal form by .1 or .01.

<u>Lessons 19 and 20</u>

26. The student will be able to multiply a number in decimal form by a number in decimal form.

<u>Lesson 21</u>

27. The student will be able to divide a number in decimal form by .1 or .01.

<u>Lessons 22 and 23</u>

28. The student will be able to divide a number in decimal form by a number in decimal form.

<u>Lessons 24 and 25</u>

29. The student will be able to solve word problems involving multiplication or division of decimals.

<u>Lessons 26, 27 and 28</u>

30. The student will be able to add two rational numbers given in fraction form.
31. The student will be able to subtract two rational numbers given in fraction form.
32. The student will be able to solve word problems involving adding and subtracting of fractional numbers.

Lessons 29 and 30

33. The student will be able to change fractions to mixed numerals.

34. The student will be able to use mixed numerals as operators.

Lessons 31 and 32

35. The student will be able to add and subtract with mixed numerals when no regrouping is involved.

36. The student will be able to add with mixed numerals when regrouping is involved.

Lessons 33, 34 and 35

37. The student will be able to subtract with mixed numerals when regrouping is involved.

38. The student will be able to solve word problems involving fractions.

Lessons 36 and 37

39. The student will be able to find a percent of a quantity.

Lessons 38, 39 and 40

40. The student will be able to change from fractions to percents.

41. The student will be able to solve word problems.

APPENDIX D

Data Collection Form A

Data Collection Form B

DATA COLLECTION FORM A

SCHOOL ______________________ TEST ______________________

TREATMENT GROUP ______________ DATE ______________________

TEACHER ______________________ SEX ______________________

Student's Name	Age Yrs. Mos.	Concepts	Score Computation	Total

DATA COLLECTION FORM B

SCHOOL ______________________ TEST ______________________

TREATMENT GROUP ______________________ DATE ______________________

TEACHER ______________________ SEX ______________________

Student's Name	Total Score

APPENDIX E

Profiles of Teachers

Table 9

Profiles of Teachers

	Age	Sex	Marital Status	Degree Held	Years at Present School	Years Exp.	Years Teaching 6th Grade	Under Grad. Major
Experimental Groups								
A	51	F	S	MA	7	29	7	Elem. Ed.
B	40	F	M	BS	9	15	6	Elem. Ed.
C	35	M	M	MA	6	11	6	Elem. Ed.
D	50	F	M	M. Ed.	11	27	11	Elem. Ed.
Control Groups								
E	50	M	M	BA	12	19	15	Soc.
F	34	F	S	BS	5	12	11	Elem. Ed.

APPENDIX F

A Study of Attitude Toward Arithmetic

A STUDY OF ATTITUDE TOWARD ARITHMETIC

W. H. Dutton
University of California, Los Angeles Form C, Scale 5, 1962

Name ______________________ Male ___ Female___ Grade in School _____

Age ____________________ I.Q. _______ Mathematics taken ___________
YEAR MONTHS (College students only)

School Attending ____________________ Date of Test __________ 19 ___

Read the statements below. Choose statements which show your feelings toward arithmetic. Let your experiences with this subject in the elementary school determine the marking of items.

Place a check (✓) before those statements which tell how you feel about arithmetic. Select only the items which express your true feelings--probably not more than five items.

___ 1. I avoid arithmetic because I am not very good with figures.
___ 2. Arithmetic is very interesting
___ 3. I am afraid of doing word problems.
___ 4. I have always been afraid of arithmetic.
___ 5. Working with numbers is fun.
___ 6. I would rather do anything else than do arithmetic.
___ 7. I like arithmetic bacause it is practical.
___ 8. I have never liked arithmetic.
___ 9. I don't feel sure of myself in arithmetic.
___ 10. Sometimes I enjoy the challenge presented by an arithmetic problem.
___ 11. I am completely indifferent to arithmetic.
___ 12. I think about arithmetic problems outside of school and like to work them out.
___ 13. Arithmetic thrills me and I like it better than any other subject.
___ 14. I like arithmetic but I like other subjects just as well.
___ 15. I never get tired of working with numbers.

16. Place a circle around one number to show how you feel about arithmetic in general.

1 2 3 4 5 6 7 8 9 10 11

Dislike Like

17. My feelings toward arithmetic were developed in grades:
    1 2 3 4 5 6 7 8 9 10 11 other _________ (Circle one)

18. My average grades made in arithmetic were:
    A B C D (Circle one)
    4 3 2 1

19. List two things you like about arithmetic.

    a.

    b.

20. List two things you dislike about arithmetic.

    a.

    b.

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THE EFFECT OF THE HAND-HELD CALCULATOR ON MATHEMATICS
ACHIEVEMENT, ATTITUDE AND SELF CONCEPT
OF SIXTH GRADE STUDENTS

by

Edris Whitted Jones

(ABSTRACT)

The purpose of this study was to investigate the effects of the hand-held calculator on the mathematics achievement, attitude and self-concept of sixth grade students. It further attempted to compare achievement, attitude and self-concept between female and male students using the calculator with those performing without the calculator.

The sample consisted of six intact sixth grade classes (171 students). Two classes using hand-held calculator (experimental group) involved 113 students and one class using paper and pencil only (control group) involved fifty-eight students. The groups were located in two schools in two different school districts. A random selection identified the classes as experimental or control. Each treatment period was fifty-five to sixty minutes daily for a duration of nine weeks.

Science Research Associates Assessment Survey, Form E scores were used as pretest data. Posttest data included form F of SRA, an Attitude Toward Arithmetic Scale and The Piers/Harris Children's Self Concept Scale. A Multivariate Analysis of Variance was used to analyze

data obtained and to test the hypothesis. F tests were used, whenever appropriate, to determine the significance of the pretest-posttest differences for both treatment and sex.

Findings of this study indicated that students using calculators demonstrated significant gains ($P < 0.001$) in total mathematics achievement, computation and concepts and there were significant differences between female and male students on concept scores. No significant differences were found between female and male in: (1) total mathematics achievement, (2) computation, (3) attitudes or (4) self-concept nor were any differences found in: (1) attitudes or (2) self-concept of all students.

Ten students in the control group admitted that they had used calculators at home during the experiment. A separate multivariate analysis of covariance excluding these ten students, was used to determine if the same results would be obtained. No significant differences were found when these students were dropped from the analysis.

The following conclusions were drawn from the findings. Using hand-held calculators was more effective in total mathematics achievement, computation and concepts than using pencil and paper only. Further concept scores between females and males were affected in favor of the experimental females.

Further research is recommended to determine if calculators would serve as a motivational source for slow students and be more effective with low income, primary students. It also appears that there is a need for mathematics educators to develop new instruments for measuring the effectiveness of technologically produced instructional aids.