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The effect of computer-assisted instruction in improving mathematics performance of low-achieving ninth-grade students

Thomas Everett Bailey
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**The effect of computer-assisted instruction in improving
mathematics performance of low-achieving ninth-grade students**

Bailey, Thomas Everett, Ed.D.

The College of William and Mary, 1991

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**THE EFFECT OF COMPUTER ASSISTED INSTRUCTION
IN IMPROVING MATHEMATICS PERFORMANCE OF LOW
ACHIEVING NINTH GRADE STUDENTS**

**A Dissertation
Presented to
The Faculty of the School of Education
The College of William and Mary in Virginia**

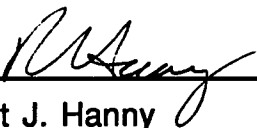
**In Partial Fulfillment
Of the Requirements for the Degree
Doctor of Education**

**by
Thomas E. Bailey
November 1991**

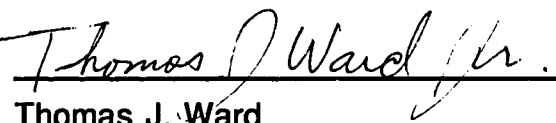
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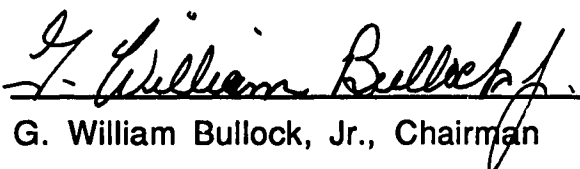
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ABSTRACT

THE EFFECT OF COMPUTER ASSISTED INSTRUCTION IN IMPROVING MATHEMATICS PERFORMANCE OF LOW ACHIEVING NINTH GRADE STUDENTS

Thomas E. Bailey, ED.D.

The College of William and Mary in Virginia, December 1991

Chairman: Dr. G. William Bullock, Jr.

The purpose of this study was to determine whether computer assisted instruction of mathematics produces significantly greater improvement in mathematics performance of low achieving ninth grade students than teaching mathematics skills without computer assisted instruction.

The sample consisted of four classes (N=46) of ninth grade students who had registered for the course "Mathematics Nine," and whose eighth grade ITBS scores fell between the 1st and 30th national percentile. Identified students were randomly assigned to one of four instructors and one of two instructional groups (computer assisted instruction or non computer instruction). Two classes with different instructors were taught the standard 9th grade mathematics curriculum augmented with computer instructed drill and practice, simulation, and games. Two classes with different instructors were taught the standard 9th grade mathematics curriculum with the conventional (teacher directed) instructional technique without computer assisted instruction. The treatment group used 16 Apple IIe microcomputers. Treatment and control groups were taught at alternating periods 3rd through 6th

for 50 minutes daily. The Iowa Test for Basic Skills mathematics subtest and the Test of Achievement and Proficiency mathematics subtest were administered to all students as pretest-posttest measures of student performance in mathematics. A system wide standard exam was administered first and second semester to assess student performance in terms of the divisions mathematic program and as multiple indicators of treatment effect.

The major findings of the study were:

1. Significant differences ($p < .05$) in total mathematics achievement gains were found between students receiving computer assisted instruction and those not receiving CAI. Students receiving CAI increased mean scores on ITBS/TAP from the 11th percentile to the 30th percentile.

2. No significant differences ($p < .05$) in computation, concepts, and problem solving achievement gains- were found between students receiving computer assisted instruction and those not receiving CAI.

3. No significant differences ($p < .05$) were found in the performance of the non-computer and the computer groups on the division city-wide exams.

Chapter 1

Introduction

During the 1980's, microcomputer use increased in American classrooms as over two million microcomputers became part of the available educational aids. With the increase of microcomputer use, came the requirement or recommendation for inservice programs for prospective teachers and current staff to enhance their understanding of the technology related to the use of computers. Many prospective teachers have been asked to comment on their experience and training in the use of computers. Just how this technology can and should be used to impact on students has received diverse reactions. Although some educators cite the research of Kulik, Bangert, and Williams (1983); Ragosta, Holland, and Jamison (1982) in showing the effectiveness of computer assisted instruction (CAI), others question whether findings of such research may be generalized to the typical school with one computer per 50 or more students. M.I.T. Computer Professor Joseph Weizenbaum sees the computer enthusiasts as having no sense of limits. To assert that all human knowledge is encodable in terms of

zeros and ones is philosophically difficult for him to accept. Weizenbaum believes that to think this way is in effect suggesting that the whole world is made to seem computable. Bear (1984) suggests that few educators actually know the impact that computers have within the educational environment in improving learning. School system administrators are cautioned to examine systematically the impact of CAI on student learning and to develop program changes based on the data collected. Until critical attributes of CAI with microcomputers can be determined, Ebel (1982) argues one would be wise to use microcomputers in association with the existing knowledge of school and teacher effectiveness.

In a more positive context, Smith (1973) concludes that CAI facilitates realistic student attitudes and reduces the fear of failure by individualizing the delivery and content of instruction. He observed that students have an overwhelming enthusiasm for CAI programs as evidenced by prompt attendance, disappointment in computer down time, and by expressions of support for change from class routine. Kinnaman's (1990) research data lends support to

Smith's findings. After synthesizing a decade of CAI research findings and eliminating studies with problems in design, Kinnaman (1990) asserts the data shows positive results from the use of computer technology in the classroom. Kinnaman (1990) suggests the following generalizations. In classrooms where some type of computer assistance is used, pupils learn more. Students receiving instructional help from computers respond very positively to the instruction. There is no significant attitude change toward subject matter when using computers, and achievement gains are fairly consistent when computers are used as a supplement to regular classroom instruction, and achievement findings are mixed, however, when CAI is substituted for conventional instruction. While some researchers comparing computer-based instruction with conventional classroom instruction have reported that well-designed computer-assisted instruction can be more effective than conventional instruction, the findings to date are positive, but inconclusive.

Statement of the Problem

The purpose of this study was to examine instructional

techniques employed in the teaching of mathematics to low achieving mathematic students. Specifically, the study was designed to determine whether computer assisted instruction of mathematics produces significantly greater improvement in mathematics performance of low achieving ninth grade pupils than teaching mathematic skills without computer assisted instruction.

Theoretical Basis and Importance of the Study

This study was designed to contribute to an understanding of the CAI research findings and to provide needed supplementary data on specific classroom situations. It was designed also to meet the three guidelines that Kulik (1981) followed for his meta-analysis of 51 studies. The three guidelines are: the research was conducted in an actual classroom within grade levels 6-12, reported measured outcomes of CAI and control groups, and methodological flaws were minimized. Kulik, Bangert, and Williams (1983) reported only eighteen studies of Kulik's (1981) meta-analysis of 51 studies assigned subjects by random and lasted longer than eight weeks. This study will contribute to the CAI data to account for CAI effects related to longer study duration with subjects randomly assigned.

The study length of one year was designed to allow novelty effect of treatment to dissipate.

Burns and Bozeman (1981) analyzed and summarized the research findings of computer-assisted mathematics instruction in elementary and secondary schools to determine the relationship of CAI and mathematics achievement. The analysis suggested that a significant enhancement of mathematics learning occurred in teaching settings supplemented with CAI. They noted, however, that CAI would be influenced by numerous variables which educational practitioners need to understand. This study will contribute to that understanding by gaining data on student computer time, software used, number of computers, and the use of CAI as a supplement to conventional instruction.

Ebel (1982) stated that schools seldom evaluate the results of their programs, but instead concentrate on the attractiveness of the process. As a counter to that error in focus, he suggested that no instructional program should be developed or continued without evidence of its effectiveness in producing learning. As Kulik, Bangert, and Williams (1983) assert, the effects of computer-based

instruction seem clear in studies of disadvantaged and low aptitude students, but the relationship hinted at must be investigated in further studies. This study focused on the effects of computer-assisted instruction on the performance of low achieving mathematics students.

General Research Hypotheses

The null hypotheses tested in this study were as follows:

Hypothesis H₀₁: students receiving computer assisted instruction on mathematics skills will show no significantly greater gains on a quantitative measure of mathematics skills than students receiving instruction with conventional teaching methods.

Hypothesis H₀₂: students receiving computer assisted instruction in computation, addition, subtraction, multiplication, and division with numbers of mathematics will show no significantly greater gains on a quantitative measure of computation than students receiving instruction with conventional teaching methods.

Hypothesis H₀₃: students receiving computer assisted instruction in concepts, knowledge of mathematical facts or

principles, will show no significantly greater gains on a quantitative measure of concepts than students receiving instruction with conventional teaching methods.

Hypothesis H₀₄: students receiving computer assisted instruction in problem solving, the selection and application of appropriate knowledge, skills and techniques in solving problems, will show no significantly greater gains on a quantitative measure of problem solving than students receiving instruction with conventional teaching methods.

Limitations Of The Study

Since the sample population was taught in a homogeneous grouping of low level students, the findings may not be generalized to different groupings and levels of students. With the use of commercial software in assisting instruction in a classroom with a ratio of microcomputers to students of nearly one to one, no attempts should be made to generalize findings to classrooms which differ greatly in the quality of software or the ratio of students to microcomputers. The additional geographic limitation associated with the sample population selected from one school in one school

division may restrict the findings to be generalized to other school divisions and schools which demonstrate the effect for the specific conditions which the experimental and control group have in common.

Definition Of Terms

For the purposes of this study, the following definitions apply:

Dependent Variables. Student test scores from the individual subtests area of Total Math, and subskill areas of Computation, Concepts, and Problem Solving from the Iowa Tests of Basic Skills Mathematical Subtest and the Test of Achievement and Proficiency, and City-wide semester exam scores.

Computer Assisted Instruction. A method of using microcomputers as an instructional tool to present individualized instructional material. The computer programs assist students in learning mathematic skills of concepts, computations and problem solving.

Microcomputer. A microcomputer is a computer whose main central processing unit is a single chip. It is a small computer system with limited potential for memory. Most microcomputers

are not capable of accessing more than about 64K of memory.

Directed Teaching.(Hunter Model). Referred to as explicit teaching, it involves a deductive approach in which specific skills are taught to students in some systematic way.

Organization of the Study

Chapter 1 included an introduction, a statement of the problem, the importance of the study, research hypotheses, limitations of the study, and definition of terms. The remainder of the study is organized into four chapters. In Chapter 2, a comprehensive review of the previous research and literature having a direct bearing on the problem is presented. The methodology of the study is described in Chapter 3 to include instrumentation, statistical hypotheses, and experimental design. In Chapter 4, data collected during the study are reported and analyzed. The study culminates with Chapter 5 which includes a summary of findings, stated conclusions, implications discussed, and future research suggested.

Chapter 2

Review of Literature

Context

While some educational computer advocates suggest that schools will shrivel and die if educators do not recognize the potential of computer use, most educators and computer advocates understand that the schools provide too many functions in society simply to replace them with computer networks and public information systems. Coburn, et. al. (1982) expressed the feelings of both the optimist and the pessimist as to the possible effect schools may experience in a computerized society. As optimists, it was said that we see schools sharing large-scale networks, allowing students and staff immediate access to information heretofore too expensive to acquire, greater family involvement in their children's education as computers allow more people to work at home, better performance in the basic skills of reading, writing, and mathematics, as people master new computer skills replacing the basic skills as we know them, and computers counteracting the negative effects of television by promoting active, creative, and

individualized behavior in children. As pessimists, it was noted that we see greater decline in computational skills as the computer is used more in our daily lives, greater truancy and resistance to learning as schools cannot give students the immediate excitement of computer games, increased violent behavior in schools as students play more arcade games killing space invaders, an erosion of the printed materials as more time is spent on computers than with books and magazines, and greater pressures on schools to provide equity in computer use, thus, creating the potential to widen the gap between rich and poor school divisions. The computer optimists believe that computers will allow for more effective ways to accomplish educational goals. The computer skeptics suggest that teachers are not ready for computers. These skeptics cite the current demands of teaching, training required for teachers, or lack of desire of teachers to develop computer skills as some of the shortcomings to computer acceptance.

However, some teachers do use computers as tools to help students think and learn in new, exciting ways. As used, the computers are intended to augment and increase curriculum

effectiveness. Reports from education reform movements have addressed the concern of declining student achievement, and most states have engaged in plans to address the decline. Virginia's governor in 1986 charged a task force to develop a plan to improve student achievement. One of the strategies recommended by the task force to impact on student achievement was the requirement that middle school level students pass a literacy test in reading, writing, and mathematics prior to entering high school. With the adoption of this recommendation by the General Assembly, school divisions were mandated to provide remedial programs for students scoring in the lower quartile of the Virginia State Assessment Program and for students failing the literacy tests at the sixth grade level. Cannaday (1990) reported that the State Superintendent of Public Instruction distributed a resource document in 1988 describing several critical elements of an effective remediation program. One of the strategies listed in the resource document was computer assisted instruction.

Computer Assisted Instruction (CAI)

Reviews of CAI research indicate that drill and practice CAI

has a positive impact on student achievement in mathematics. The effectiveness of CAI drill and practice with elementary students when measured by standardized achievement tests was evaluated by Suppes and Morningstar (1969). Students in the control and treatment groups were administered the Stanford Achievement Test as a pretest and posttest. The tests were given in four California schools during the 1966-67 school year. They discovered that one of the California schools had added 25 minutes per day of classroom instruction and practice in mathematics. This intensive effort of classroom drill and practice by the teacher proved to be as effective as drill and practice on the computer. However, it was concluded that drill and practice on the computer took less time and did not require any extra help from the teacher. Vinsonhaler and Bass's (1972) study support these findings in concluding that when measured by standardized achievement tests, CAI was significantly more effective than traditional instruction.

Burns and Bozeman's (1981) meta-analysis study reported that CAI drill and practice were significantly effective in increasing mathematic achievement of elementary and secondary students.

The findings were reported for mathematic instructional programs which used CAI as a supplement to conventional classroom instruction. Student achievement gains were significant among highly achieving and lower achieving students with average level students showing no significant gain.

Within the context of CAI improving achievement of low performing students, Lang, Branch, and Thigpen's (1987) study lends support to Burns and Bozeman's findings. Lang et al., (1987) reported computer-based instruction produced significant achievement gains on the Comprehensive Tests of Basic Skills for 4,293 remedial ninth through twelfth graders as compared to conventional classroom instruction.

Jamison, Suppes, and Wells (1974) studied the effectiveness of alternative instructional media and concluded in their survey findings that while CAI attempts to improve instruction by providing for individualization there is no significant difference in achievement. However, some studies supported a savings in student time and concluded that small amounts of CAI used with elementary students as a supplement to regular instruction produce an

improvement in achievement, especially for slower students.

Most of the early studies reviewed were conducted in elementary schools. Conclusions of these evaluation studies generally supported the effectiveness of CAI at the elementary level when used in supplement with conventional instruction. In a less positive context, Gilman and Brantley (1988) reported no significant achievement differences were observed between 28 fourth grade students receiving instruction by traditional teaching methods and one computer in the class as compared to 29 fourth grade students receiving a minimum of two hours per day of CAI with traditional instruction and one computer per two students. Gilman and Brantley suggest that study results may have been affected by quality and relevance of software, no random selection of students, and the two month absence of the CAI teacher.

At the college level, Kulik, Kulik, and Cohen's ((1980) meta-analysis integrated the findings from 59 studies on the effectiveness of computer-based college teaching. Their analysis focused on the effects of computer-based instruction and conventional teaching at the college level. To be included in the

sample, a study had to meet three criteria. The study had to focus on college classroom instruction, report on quantitatively measured outcomes, and the studies had to be free of methodological flaws. The 59 studies demonstrated four major types of computer applications to instruction: tutoring, computer-managed teaching, simulation, and computer programming to solve problems. Of the 59 studies, 54 investigated the effect of CBI compared to conventional classes as measured by examination performance. Findings supported CBI examination performance over conventional examination performance. The effect of CBI was concluded to raise student achievement by one-quarter of a standard deviation unit. All of the studies tested for significance in evaluating the differences in instructional time between CBI and conventional classes showed statistical significance. For student instructional time, it was reported that with the conventional approach 3.5 hours of instructional time per week were needed as compared to 2.25 hours for the computer-based approach. Kulik et al., (1980) concluded that CBI had made a small but significant contribution in the effectiveness of college instruction as evidenced by a student in

a CBI class would score at the 60th percentile on an examination and a student in a conventional class would score in the 50th percentile.

While CAI research conclusions generally support the effectiveness of CAI, educators should evaluate the beneficial effects of CAI conclusions based on the context in which CAI is administered. Gourgey (1987) studied three conditions of administration of drill and practice: CAI with formal classroom instruction, CAI with reinforcement for good performance, and CAI alone. While Gourgey's (1987) study demonstrated the beneficial effects of CAI in general, it offered additional empirical evidence that instructional outcomes were significantly affected by the context in which the CAI was managed. Gourgey's study reported improved achievement in reading and mathematics for seventy-seven grade 4 to 8 remedial students who had been divided into three groups: those receiving CAI lessons with formal classroom instruction, those receiving CAI instruction with reinforcement for good performance, and those receiving CAI alone. Although all three groups gained in achievement, there was significant differences associated with the type of administration and its affect on CAI

effectiveness. Reinforcement for good performance was most effective for reading, while CAI with formal classroom instruction and CAI alone showed no significant difference. In mathematics, CAI with formal classroom instruction was most effective, while CAI alone and CAI with reinforcement demonstrated no significant difference. It should be noted that CAI alone was not significant in either context. Jamison et al., (1974) supported Gourgey's general findings by concluding that computer-based teaching, when it is coordinated with regular instruction, improved performance scores for disadvantaged elementary students. This conclusion was consistent with the synthesis of empirical research on computer-based instruction. Gourgey (1987) stated that with the proliferation of computer assisted instruction (C.A.I.), education was considered to be going through a "computer revolution". He also stated that the possession of sophisticated technology will not insure quality education and suggested an important issue in using CAI was the identification of factors which maximize student gains. Kulik (1983) revealed that factors (study features) in his meta-analysis of findings from 51 computer-based teaching studies in grades 6

through 12 disclosed only two features, year of publication and study duration, with borderline levels of statistical significance. Kulik's findings revealed that final examination scores were higher in most recent studies and in studies of shorter duration. While only two features had some statistical significance, (Kulik, Bangert, and Williams, 1983) concluded that computer-based teaching raised student's scores on final examinations by approximately .32 standard deviations or from the 50th to the 63rd percentile. Other findings concluded that student retention improved; student attitudes toward computers and the course were positive; and student learning time was reduced with computer based instruction. It is important to note that Kulik (1983) suggested that the stronger effects of publication year and study duration were due to improved instructional technology used in more appropriate ways. Kulik's hypothesis was supported by (Cox, 1980; Signer, 1982) who reported that the few field studies conducted with microcomputers were flawed by insufficient equipment, poor quality software, and inadequate computer access time for students.

Most of the CAI research literature supports CAI having a

positive effect on the improvement of elementary student achievement. Kulik (1983) reported the first systematic reviews conducted on CBI demonstrated its effectiveness in improving elementary student scores, especially when CBI was used to supplement traditional instruction. Kulik referred to Vinsonhaler and Bass (1972) and Edwards and others (1975) whose findings concluded a positive relationship to CBI's effectiveness in raising student achievement. In their summary of ten major studies on CAI drill and practice, Vinsonhaler and Bass (1972) concluded that elementary students receiving computer assisted drill and practice demonstrated performance gains of one to eight months when compared to students receiving traditional instruction. When CAI effectiveness is measured by standardized achievement tests, Vinsonhaler and Bass (1972) concluded strong evidence for CAI effectiveness as compared to traditional instruction. Edwards and others (1975) review of CBI studies included four modes of CAI: drill-and-practice, problem solving, simulation, and tutorial. When CAI was used as a supplement to traditional instruction, all studies concluded that supplemental traditional instruction with CAI was

more effective than traditional instruction alone. When CAI replaced traditional instruction, nine studies reported CAI students achieving more than the non-CAI students, and eight studies reported little or no difference. Several of the studies revealed mixed results. The effectiveness of CAI modes revealed that each mode of CAI was more effective than traditional instruction in some studies and as effective as traditional instruction in other studies. Of the four modes of CAI, no mode was found to be any more effective than another mode. Edwards and others (1975) concluded their review of the research on how effective is CAI, in reporting that all studies revealed that it took less time for students to learn using CAI than other methods, that while students may learn more quickly using CAI their retention may not be as great as students receiving traditional instruction, and while only two studies tested CAI effectiveness according to ability level, both found CAI drill and practice in mathematics to be more effective with low ability students. It is interesting to note that Kulik, Kulik, and Cohen (1980) meta-analysis of 59 independent evaluations of computer-based college teaching concluded that college students

had small but significant course achievement gains with CBI, showed positive student attitudes toward instruction and course material, and CAI reduced the time needed for instruction.

Computer Assisted Instruction, Mathematics/Remediation

In the early 1980's, little CAI research had been conducted or published on the effects of CAI in teaching mathematics. One of the few attempts to synthesize and collect experimental studies on the effectiveness of techniques used in mathematics instruction was Hartley's (1977) meta-analysis of one hundred fifty-three experimental studies. Hartley's (1977) meta-analysis studied the effectiveness of the four teaching techniques of: computer-assisted instruction, crossage and peer tutoring, individual learning packets, and programmed instruction. Each technique was compared to the achievement of students by traditional methods. Tutoring was found to be the most effective technique with CAI reported as considerably more effective than individual learning packets or programmed instruction. Her findings concluded that CBI raised student achievement from the 50th to the 60th percentile. Gourgey (1987) studied three administrative conditions of drill and practice CAI

with 124 4th to 8th grade level remedial students. Students were assigned to CAI coordinated with formal classroom instruction, CAI with positive reinforcement for good behavior, and CAI alone. Gourgey (1987) concluded that CAI with coordinated instruction was most effective in mathematics achievement and that formal instruction augmented with CAI was essential for conceptual understanding. For mathematics, an increase in achievement for conceptual skills and computation skills was obtained when formal instruction was coordinated with drill-and- practice CAI. Gourgey's (1987) study posited the position that CAI provided the opportunity for practice using the actual mathematical procedure and formal instruction allowed for explanatory teaching of mathematical concepts. Gourgey concluded the two were inseparable in raising mathematics achievement. While the results of Gourgey's (1987) study support the previous research findings of drill-and-practice to improve student achievement, it is possible that the results could have been influenced by the study's limitations. Students were assigned to the treatment groups by the teachers and administration, students were not randomly selected for the study, and initial

achievement levels of students were not matched in the treatment groups.

Some of the most recent research findings on microcomputers which suggest an importance to elementary and secondary teachers is reported in Suydam (1986) in her overview of research: computers in mathematics education, K-12. Findings are reported in the areas of tutorial, drill and practice, games, computer-managed instruction, and attitudes. Tutorial findings are mixed on student mathematics achievement. Suydam (1986) concluded that CAI tutorials produced higher achievement gains than did conventional instruction in most cases; no significant differences in achievement were found in a few studies, and in at least one study achievement was statistically significant to the amount of student computer time. Only one study favored the non-computer groups. When based on cost per unit of achievement gain, or on the value of mathematics competency by parents and school boards, Hawley (1986) reported CAI to be considered more cost effective than non-computer conventional instruction.

Eight of the twelve studies on drill and practice concluded no

significant achievement gains between computer and non-computer groups. Only four of the 12 studies reported higher achievement gains with drill and practice CAI. Drill and practice was reported to be effectively administered by computers but no more effective than a teacher providing drill and practice in conventional methods.

Games were reported as reinforcing and motivating. They served as extrinsic reinforcers. Computer game groups correctly answered twice as many questions in a speed test on addition facts as did the non-computer game group. College students related to the games at a higher level than eighth graders. College students used the games to problem solve while only one half of the eighth graders viewed the games from the problem solving context. Eighth graders used random trial and error to solve the problems.

Computer-managed instruction studies were few in considering mathematics instruction. No difference was reported in student achievement in the three studies considered. However, teachers expressed preference for microcomputer-managed systems to non-computer systems.

Findings on student attitudes reported that most students like

to work with computers regardless of ability levels and sex. Positive correlations were reported between attitudes toward computers and attitudes toward mathematics. Suydam (1986) concluded her overview by stating that with more research in the use of computers in mathematics, we should acquire greater detailed data on how to use computers more effectively .

In developing a remedial instruction program to meet the basic skills of Coast Guard recruits, Glidden (1984) integrated a computer assisted instruction program with Navy conventional materials. The results demonstrated an overall increase of 6.8 percentile on the ASVAB verbal and mathematics sections. An additional dimension of CAI was suggested by Glidden and others (1984), who found CAI to be most effective when the software was presented after classroom instruction, rather than before. McConnell's (1983) study supported Glidden's study. The computer program was used in McConnell's study to reinforce mathematic skills rather than providing the initial instruction. Five hundred students in grades 3 to 6 received either CAI, paper and pencil drill and practice, or the regular curriculum. The study revealed that CAI increased scores in

total mathematics and computation skills significantly as compared to the other treatments; however, greater improvement in concept application skills was accomplished by the regular curriculum.

These findings were demonstrated for remedial programs as well.

An additional conclusion reached was that a positive correlation exist between length of computer time and achievement gains. The study showed that the more time students had on the computer the greater the achievement gains. Findings of McConnell's study with two groups of students have been replicated suggesting that CAI can be an effective program to improve student's basic mathematic skills. Studies by Jamison et al., (1974) and Edwards, Norton, Taylor, Weiss, and Dusseldorp (1975) concluded that computer-based teaching reduced student time in learning. Kulik et al., (1980) supported this finding which stresses the importance of computers in reducing instructional time. Hotard and Cortez (1988) stated that CAI time is directly related to increased remedial gain.

Specifically, they concluded that spending less than 12 hours a year on CAI would result in minimal achievement gain. Ten minutes of drill and practice a day, resulting in a maximum of 22 hours a year

of CAI, have produced growth in a variety of skills, equal to 1 to 2 years of class work. This study used CAI in a remedial program for Chapter I disadvantaged students in Lafayette Parish, Louisiana. CAI produced gains above the national average for Chapter I students for four years in grades 5 to 8. While Hotard and Cortez (1988) studied the middle grade levels, Lang and others (1987) analyzed the effects of CAI on achievement of 4,293 remedial high school students in grades 9 to 12. They found CAI to be effective as significant student gains were made on the comprehensive Test of Basic Skills. It should be noted that Kulik, et. al. (1983) meta-analysis of 51 studies suggested that educators should not anticipate CAI to be as effective with college and high school level students as with elementary level students. Kulik (1981) emphasized this conclusion for mathematics education after his synthesis of findings and those of Hartley (1977). Kulik posited that the computer provided the needed stimulation and guidance for the elementary level student. With the secondary student, he suggested that some students may actually object to the highly reactive and structured programs. As Bear (1984) stated, the consideration of

student differences should be of primary importance in the selection or design of CAI software. Software that is motivational and effective with elementary level students may not be worthwhile with secondary students.

Of particular importance in the review of CAI literature, was the tendency of more recent studies to report stronger effects of CAI on student achievement (Kulik et al., (1983). They attributed this tendency to educators making more appropriate use in recent years of the instructional technology.

While there was empirical data on the effectiveness of CAI, Ragorta et al., (1982) suggested caution in transferring previous research findings to the microcomputer period. The ratio of computers to students, the quality of the software, student time on computers, match of software to the curriculum and tests used to evaluate the programs, teacher management, age appropriate software, and computer-literate teachers are all characteristics which impinge upon the implementation of successful CAI programs. Research findings are far from being conclusive to the effect of CAI in improving learning as compared to conventional instruction.

Edwards et. al., (1975) stated that 40 percent of the studies reviewed demonstrated little or no difference in student learning when CAI augmented or replaced conventional instruction. Serious flaws exist in the research design of many CAI studies. In Kulik et al., (1983) meta-analysis of 51 studies, only 18 studies used random assignment of subjects. Becker's (1987) synthesis reported only one study of 51 to have true random assignment. Due to the lack of randomization in CAI research, Kulik et al.,(1983) and Becker (1987) reported previous CAI research findings may be the result of other variables impacting on student achievement other than the different modes of CAI investigated.

Summary of Research and Relationship to the Problem

The CAI research literature has provided practitioners with the theoretical and empirical foundation in examining CAI as a viable teaching technique. Research has shown CAI's effectiveness in remediating student mathematics performance within different grade and ability levels. The studies of Jamison et al., (1974), Hartley (1977), Kulik (1983), Kulik et al., (1983), Suydam (1986), Gourgey (1987), and Hotard and Cortez (1988) have reported evidence

of CAI's effectiveness in improving student achievement, especially at the elementary level. CAI was reported to raise student's scores on final examinations by approximately .32 standard deviations or from the 50th to the 63rd percentile, Kulik et.al., (1983).

While significant CAI research has reported positive results of CAI's effectiveness in improving student achievement, the CAI findings are not conclusive. As Ragosta et al., (1982) suggested, caution is warranted in transferring previous research findings to the microcomputer period. Research literature analysis has shown programs labeled as CAI differ in many characteristics. As Burns and Bozeman (1981) reported, the final answers related to CAI's effectiveness can not be presented, but the analysis of many studies conclude CAI's effectiveness in the area of mathematics. Further research of the relationship between computer assisted instruction and its influence on mathematic achievement of low achieving students should contribute to the knowledge of how students can achieve. This knowledge would then provide the basis in developing opportunities for remediation and for increasing understanding of the computer as it relates to student mathematic achievement.

Chapter 3

Methodology

Introduction

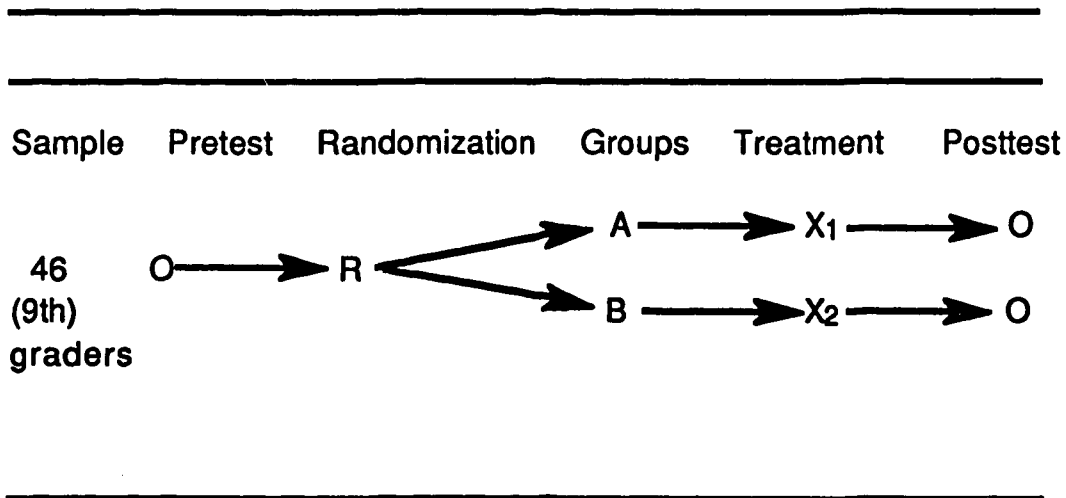
This chapter describes the research methodology used in this study. The purpose of the study was to determine whether computer assisted instruction produces significantly greater improvement in mathematics performance of low achieving 9th grade pupils than non-computer assisted instruction. Presented also are descriptions of the population sample, instrumentation, staff selection and training, instructional materials, data collection, and analysis of data.

Research Methodology

This study was designed to compare the effect of computer assisted instruction with the conventional directed teaching strategy to non-computer instruction with conventional methods (directed teaching) in improving mathematics performance of low achieving 9th grade students. Two classes with different instructors taught the 9th grade mathematics curriculum augmented with computer assisted instructed drill and practice, simulation, and games. The two non-computer groups were taught by different

teachers using an explicit, deductive teaching approach in which specific skills are taught to students in some systematic way. This instructional approach was a model of Madeline Hunter's directed teaching technique. Student subjects who were scheduled to enter the 9th grade in the fall of 1990 were randomly assigned to one of four instructors and one of the two instructional groups. Figure 1 shows the pretest-posttest comparison group design followed.

Figure 1. Pretest-posttest comparison group design.



McMillan and Schumacher (1989) stated that the design presented in Figure 1 rules out intersubject differences through randomization of subjects to groups and includes the manipulation of the treatment variable.

Two posttests were used as multiple indicators of treatment effect. An examination developed locally was administered first and second semester. This measure revealed the progress of students in terms of the school system mathematics program. The Iowa Test for Basic Skills (ITBS), (1986) and the Test of Achievement and Proficiency (TAP), (1987) were administered before and after treatment as an indicator of student mathematical performance . Form G-level 14 of the ITBS was given the 8th grade year as the pretest. Form H- level 15 of the TAP was given the 9th grade year as the posttest. The ITBS mathematics subtest contained 117 five-option, multiple-choice items. Forty-three items measured computation, 42 measured concepts, and 32 measured problem solving. The TAP mathematics sub-test contained 48 five-option, multiple-choice items. Twelve items measured computation, 15 measured concepts, and 21 measured problem solving. The tests are designed to measure students competence in the use of basic mathematical skills related to the quantitative aspects of everyday living and to assess student understanding of basic mathematical principles (Iowa Tests of Basic Skills, 1987 and Tests of

Achievement and Proficiency, 1987).

Tests items are grouped according to the content and skill involved. Each item is assigned to one of three skills areas: computation, concepts, and problem solving. Reliability coefficients for the test were computed by using the Kuder-Richardson Formula 20. Reliability coefficients of .92 and .88 were computed for Forms G and H respectively in the area of mathematics achievement. Six-month test-retest reliabilities were calculated using Pearson product-moment correlations. A coefficient of .80 for grade nine was computed for mathematics. The length of treatment was two semesters.

Population and Selection of Sample

The research site for this study was an urban high school (grades 9-12) in the Hampton City School Division of Hampton, Virginia. ITBS mathematics sub-test scores at or below the 30th percentile were used as criterion scores for selecting subjects. The population sample was identified from the feeder schools 8th grade students scoring up to the 30th percentile on the ITBS mathematics sub-test in the Spring of 1990 and receiving a D or F in their 8th

grade mathematics course.

The target population consisted of 9th grade students who had registered for the course Mathematics Nine. The target population included 59 rising 8th grade students whose 8th grade ITBS scores fell between the 1st and 30th national percentile.

Sample selection was determined by a letter (see Appendix A) and a follow up telephone call to parents explaining the study and inviting the students to participate. Ninety-four percent of the parents whose children were eligible indicated an interest in having their child participate by returning the consent form with student and parent signature. The population sample consisted of 46 students. Students were randomly assigned to the treatment (computer assisted instruction) group and to the control (no computer assisted instruction) group. Only students with pretest and posttest scores were included in the study.

Fifty-six students participated in the study of whom ten students were dropped. Three students registered for the course, returned consent forms but moved during the summer. Four students moved during the year, one student decided to drop the Mathematics

Nine course to take Pre-Algebra, one student was expelled during the year, and one student was dropped from the study prior to data analysis for failure to comply with posttests requirements.

Instrumentation

Scores on the Iowa Test of Basic Skills and the Tests of Achievement and Proficiency mathematics subtests were used to assess student performance on meeting the specific mathematic skills of computation, concepts, and problem solving. Cannaday (1990) reported that mathematic skills tested on the ITBS correlated highly with Virginia's state mandated standards of learning for mathematics. The 8th grade ITBS mathematics subtest and the 9th grade TAP mathematics subtest were examined and skills identified which would be tested under the Literacy Passport Testing Program. Mathematic objectives identified in the Literacy Testing Program were skill objectives of computation, to include addition, subtraction, multiplication, and division with numbers, concepts, to include the demonstration of knowledge of mathematical facts and principles, and problem solving, to include the selection and application of appropriate knowledge, skills and

techniques in solving problems. The Virginia State Standards of Learning (SOL) for mathematics and Hampton Mathematics SOL's were assessed for correlation to ensure that the mathematics skills were addressed in the 9th grade curriculum. The city-wide semester exam was developed by teachers to assess the skill levels identified in the 9th grade mathematics curriculum.

Form G-level 14 of the ITBS was administered the 8th grade year as the pretest and Form H-level 15 of the Test of Achievement and Proficiency was administered the 9th grade year as the posttest. The primary purpose of the ITBS and the TAP is to measure student's competence in the use of basic mathematics skills related to the quantitative aspects of everyday living. A second purpose of the tests is to assess student understanding of basic mathematical principles. The reliability of the tests as reported for the summary statistics for Forms G and H based on standardization samples and on data obtained from the equating study of spring 1986 were computed using the Kuder-Richardson Formula 20. For Form G the KR-20 was .92 and for Form H the KR-20 was .88. Test-retest reliabilities were calculated using Pearson

product-moment correlations (Iowa Tests of Basic Skills, 1986).

The coefficients were consistently high, ranging from .75 to .92 with an average of .82 showing the stability of the test over time. Scores used in analysis were reported in standard score form for the total mathematics score on the ITBS and TAP. Since UNISCORE Incorporated does not publish a standard score for the subtest on the TAP, student scores compared to the national averages were converted to percentile scores on the ITBS and TAP mathematical subtests for analysis.

Staff Selection And Training

Efforts to control for teacher variability included careful screening of the four teachers selected to participate in the study.

Teachers were required to meet three criteria:

1. Willingness to participate in the study.
2. Evidence of successful teaching of low level 9th grade students.
3. Experience in directed teaching method (Madeline Hunter Model), (Hunter, 1982).

In addition to the above three criteria, two teachers had to

have experience in computer assisted instruction. All the teacher had to use a highly structured model of lesson delivery. Teacher input was given to students on a new skill or concept with a variety of instructional aids: the chalkboard, overhead projector, filmstrips, manipulatives, pictures, posters, and VCR's. Following the structured lesson model format, teachers provided the students with appropriate models or examples for the skill being taught. Teachers checked for understanding and provided guided and independent practice activities for students. The treatment group teacher's used commercially produced computer software, (High School Math Competency Series, 1987), (MECC, 1984-1989), and Barnum, 1987) in the form of drill and practice, simulations, and games to instruct students. The control group did not use computers in the instructional process.

A standard city-wide course syllabus was provided to each teacher. Treatment group teachers were required to monitor and account for computer time through the use of a daily log. During the first semester, students received 15 hours of computer assisted instruction. For the second semester, students received 22 hours

and 30 minutes of computer assisted instruction. The project director monitored all teachers by periodic meetings to assess content pacing and adherence to study requirements. Teachers received comparable instructions, resources, and staff support to ensure equal treatment and to control for a Hawthorne effect. The project director met with the four teachers during the summer to coordinate classroom activities.

Instructional Materials

Students in both treatment groups used the same 9th grade mathematics textbooks. The computer software was commercially produced. Teachers selected the software needed to provide for drill and practice, simulation, and games as it related to all mathematics skills covered in the course. Special consideration was given to the selection of age appropriate software. The High School Math Competency Series, MECC Conquering Math Series, and the Barum Software Company program Quarter Mile were the computer programs used both semesters to provide CAI. The High School Math Competency Series provided 14 programs based on the N.Y. State Curriculum Guidelines for grades 9-12. The 14

subprograms contained on the disk were: whole numbers, fractions, decimals, basic percent, primes and factors, integers, algebra, geometry, ratio and proportion, probability, statistics, percent word problems and money problems (High School Math, 1987). The MECC Conquering Math Series program provided a series of programs providing problem solving games, drills, graphic and written remediation, and simulation to focus on specific mathematical skills and concepts. The subprograms used in the study were: (Circus Math, 1984), (Conquering Decimals, 1988), (Conquering Fractions, 1988), (Conquering Percents, 1989), (Conquering Ratios and Proportions, 1989), (Conquering Whole Numbers, 1987), (Coordinate Math, 1987), (Decimal Concepts, 1988), (Fraction Munchers, 1986), and (Number Munchers, 1986). The Barnum computer program Quarter Mile provided drill and practice in the form of an arcade game. The program focused on the mathematics area of whole numbers. Students worked on addition, subtraction, multiplication, and division of whole numbers. Correct responses produced acceleration in an arcade race car, and incorrect answers caused the race car to decelerate. Students raced against the clock

to complete the quarter mile course before time ran out.

All teachers had a full sized classroom. Students in the CAI treatment group were taught in the mathematics computer lab. The computer lab was a full sized classroom with 16 Apple IIe microcomputers. Treatment and control groups were taught at alternating periods third through sixth to control for differences of instructional time of day.

Analysis Of Data

The procedure judged most appropriate for the treatment of the data was repeated measures analysis of variance. Two advantages of the repeated measures design are fewer experimental units are required and the repeated measures provide a control on their differences. According to Norusis (1985), variability due to differences between subjects can be eliminated from the experimental error. Of the difficulties encountered with repeated measures designs, learning effect was the only problem that required attention. Learning effect is the result of performance improvement merely by the repetition of a task independent of the treatment. Learning effect was controlled for by including non-

computer instruction groups that performed the same tasks repeatedly without receiving the computer assisted instruction treatment. Wilkinson (1989) noted that the repeated measures design treats the dependent variables as a set of repeated measures. Although hypotheses tested with Manova are similar to those tested with Anova, the difference is that sets of means with Manova replace individual means in Anova. Manova is used to evaluate mean differences on two or more dependent criterion variables simultaneously. With the dependent variables, ITBS, TAP, and Exam scores being measured on an interval scale and the research question involving a comparison of mean scores, Manova was an appropriate technique. Bray and Maxwell (1985) commented from Cook and Campbell (1979) that it is almost always the case that it is better to multi-operationalize a construct, have several measures of it, rather than mono-operationalize the construct, have a single measure of it.

For all four hypotheses, the analysis was conducted as a two-step process. The first step for each hypothesis was to test the overall null hypothesis of no difference in the means for the

different groups. If statistical difference was found between the computer vs. non-computer groups, the second step of analysis required follow-up tests to be conducted to explain group differences. The first step will answer the question, did the computer assisted instructed students perform differently than the non computer students? If the answer was yes, where they did better was determined in the second step of analysis. Was it the computer assisted instructed group or the non computer group that performed better? The System for Statistics for the PC SYSTAT was used to analyze data. A .05 level of significance was used in the study as suggested by Cook and Campbell (1979) as the standard to accept or reject the null hypotheses for educational research.

Summary of Methodology

This study tested the effectiveness of computer assisted instruction in improving the mathematical performance of low achieving 9th grade students. A pretest-posttest comparison group design was used to compare computer assisted instruction groups to non-computer instruction groups. The target population consisted of 9th grade subjects placed below the 30th percentile on the 8th

grade ITBS. The Test of Achievement and Proficiency mathematics subtests was used to measure student changes in the mathematical skills of computation, concepts, and problem solving. A repeated measures analysis of variance was used to test the statistical significance of the relationship between the computer and non-computer groups. The resultant data was analyzed by the System for Statistics for PC (SYSTAT) and is presented in Chapter 4.

Chapter 4

Analysis of Results

Introduction

The purpose of the study was to examine instructional techniques employed in the teaching of mathematics to low achieving mathematic students. Specifically, the study was designed to determine whether computer assisted instruction of mathematics produces significantly greater improvement in mathematics performance of low achieving ninth grade pupils than teaching mathematics skills without computer assistance. Student mathematic performance was measured by pretests and posttests which were administered under similar testing conditions. For semester exams, testing was administered in the regular classrooms by study teachers. For the ITBS and TAP, testing was administered by grade levels in group settings by guidance counselors and teachers in the middle school for pretest and the high school for posttest. The ITBS and TAP were scored by UNISCORE, Incorporated. The resultant data was analyzed by the System for Statistics for PC (SYSTAT).

The analysis of data was computed using a repeated measures analysis of variance. The analysis was conducted as a two-step process. First, the overall hypothesis of no difference in the means was tested. If this step was significant, follow-up tests to explain group differences were conducted. The first step answered the question, did the computer assisted instructed students perform differently than the non-computer students. If the answer was yes, where they were different was determined. Was it the computer assisted instructed group or the non-computer group that performed better? Follow-up tests explained group differences for each of the skill areas studied.

Hypothesis Ho1

This hypothesis states that students receiving computer assisted instruction on mathematics skills will show no greater gains on a quantitative measure of mathematics skills than students receiving instruction with conventional teaching methods. The repeated measures analysis of variance looked at main effects for groups (computer vs. non-computer), time (pretest vs. posttest), and the interaction of group and time.

For the dependent variable total math score, the analysis of variance indicated effects for group ($E(1,44) = 4.924, p < .05$), time ($E(1,44) = 53.941, p < .001$), and the interaction of group and time ($E(1,44) = 6.451, p < .02$) (see Table 4.1). A table of the interaction means is presented in Table 4.2.

The repeated measures analysis of variance results for total math, indicated there was some difference between computer and non-computer groups, there was a difference between pretest and posttest, and there was an interaction between groups and time. To determine the exact location of mean differences, whether the interaction was favorable to the non-computer or computer group, a Tukey post-hoc comparison test was used. To be significant, mean differences between the non-computer and computer groups had to be greater than 17.45 as calculated using the Tukey technique.

Pretest comparisons of the non-computer to the computer group revealed no difference between the groups. Posttest comparisons of the non-computer group to the computer group also indicated no difference (see Table 4.2).

When comparing the non-computer group gains from pretest to

posttest, no significant growth is found. Comparisons of the computer group pretest and posttest scores indicated significant growth (see Table 4.2). The 17.857 gain was greater than the 17.45 required for significance using the Tukey test. Post hoc comparison data indicated that only the computer group gained. The computer group increased from a pretest mean of 141.905 to a posttest mean of 159.762. This 17.857 gain represented an increase in national percentile ranking from 11th percentile to the 30th percentile.

From pretest to posttest, the non-computer group had no significant growth. The computer group did have significant gain. Hypothesis Ho1 was rejected. Students receiving computer assisted instruction on mathematics skills showed significantly greater gains on a quantitative measure of mathematics skills than students receiving instruction with conventional methods.

Table 4.1

HYPOTHESIS 1- REPEATED MEASURES ANALYSIS OF VARIANCE ON THE NON-COMPUTER, COMPUTER, PRETEST AND POSTTEST TOTAL MATH SCORES GROUP EFFECT, TIME EFFECT, INTERACTION EFFECT

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
<u>Between Subjects</u>					
Group	620.387	1	620.387	4.924	0.032*
ERROR	5543.613	44	125.991		
<u>Within Subjects</u>					
Time	4018.646	1	4018.646	53.941	0.000*
Group*Time	480.603	1	480.603	6.451	0.015*
ERROR	3278.006	44	74.500		

* Significant at $p < .05$

TABLE 4.2

HYPOTHESIS 1 - INTERACTION EFFECT GROUP AND TIME COMPARISON OF THE FOUR MEANS OF GROUP NON-COMPUTER AND COMPUTER AND OF TIME PRETEST AND POSTTEST FOR TOTAL MATH SCORE

		GROUP	
		NON-COMPUTER	COMPUTER
T I M E	pretest	141.280 SD: 7.716	141.905 SD: 5.504
	posttest	149.960 SD: 12.654	159.762 SD: 12.132

Mean difference of non-computer group from pretest to posttest was 8.680. Mean difference of non-computer and computer groups after treatment on posttest was 9.802. Mean difference of computer group from pretest to posttest was 17.857. Tukey test required a difference greater than 17.45 to be significant. Cases analyzed: non-computer 25, computer 21.

Hypothesis H02

This hypothesis states that students receiving computer assisted instruction in computation (addition, subtraction, multiplication, and division) with numbers of mathematics will show no significantly greater gains on a quantitative measure of computation than students receiving instruction with conventional teaching methods. The repeated measures analysis of variance looked at main effects for groups (computer vs. non-computer), time (pretest vs. posttest), and the interaction of group and time.

For the dependent variable computation math score, the analysis of variance indicated effects for group ($F(1,44) = 3.115, p < .085$), time ($F(1,44) = 57.817, p < .001$), and the interaction of group and time ($F(1,44) = 2.108, p < .154$) (see Table 4.3). The repeated measures analysis of variance results for computation, indicated there was no difference between computer and non-computer groups, there was a significant gain from pretest to posttest. However, there was no significant interaction between groups and time.

Hypothesis H02 was accepted. Students receiving computer assisted instruction in computation, addition, subtraction,

multiplication, and division with numbers of mathematics did not show significantly greater gains on a quantitative measure of computation than students receiving instruction with conventional teaching methods.

Table 4.3

HYPOTHESIS 2- REPEATED MEASURES ANALYSIS OF VARIANCE ON THE
NON-COMPUTER, COMPUTER, PRETEST, POSTTEST SUBTEST
COMPUTATION SCORES GROUP EFFECT, TIME EFFECT, INTERACTION
EFFECT

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
<u>Between Subjects</u>					
Group	601.270	1	601.270	3.115	0.085
ERROR	8492.785	44	193.018		
<u>Within Subjects</u>					
Time	10173.414	1	10173.414	57.817	0.000*
Group*Time	370.979	1	370.979	2.108	0.154
ERROR	7742.206	44	175.959		

* Significant at $p < .05$

Hypothesis H₀₃

This hypothesis states that students receiving computer assisted instruction in concepts, knowledge of mathematical facts or principles, will show no significantly greater gains on a quantitative measure of concepts than students receiving instruction with conventional teaching methods. The repeated measures analysis of variance for concepts looked at main effects for groups (computer vs. non-computer), time (pretest vs. posttest), and the interaction of group and time.

For the dependent variable concepts, the analysis of variance indicated effects for group ($E(1,44) = 2.385, p < .130$), time ($E(1,44) = 3.965, p < .053$), and the interaction of group and time ($E(1,44) = 3.688, p < .061$) (see Table 4.4). The repeated measures analysis of variance results for concepts indicated there was no difference between computer and non-computer groups, no difference in pretest and posttest, and no significant interaction between groups and time.

Hypothesis H₀₃ was accepted. Students receiving computer assisted instruction in concepts, knowledge of mathematical facts

or principles, did not show a significantly greater gain on a quantitative measure of concepts than students receiving instruction with conventional teaching methods.

Table 4.4

HYPOTHESIS 3- REPEATED MEASURES ANALYSIS OF VARIANCE ON THE
NON-COMPUTER, COMPUTER, PRETEST AND POSTTEST SUBTEST
CONCEPTS SCORES GROUP EFFECT, TIME EFFECT, INTERACTION EFFECT

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
<u>Between Subjects</u>					
Group	277.948	1	277.948	2.385	0.130
ERROR	5128.356	44	116.554		
<u>Within Subjects</u>					
Time	367.307	1	367.307	3.965	0.053
Group*Time	341.612	1	341.612	3.688	0.061
ERROR	4075.606	44	92.627		

* Significant at $p < .05$

Hypothesis H₀₄

This hypothesis states that students receiving computer assisted instruction in problem solving, the selection and application of appropriate knowledge, skills and techniques in solving problems, will show significantly greater gains on a quantitative measure of problem solving than students receiving instruction with conventional teaching methods. The repeated measures analysis of variance for problem solving looked at main effects for groups (computer vs. non-computer), time (pretest vs. posttest), and the interaction of group and time.

For the dependent variable problem solving scores, the analysis of variance indicated effects for group ($F(1,44) = .012, p < .914$), time ($F(1,44) = 1.741, p < .194$), and the interaction of group and time ($F(1,44) = 1.741, p < .194$) (see Table 4.5). The repeated measures analysis of variance results for problem solving indicated there was no difference between computer and non-computer groups, no difference in pretest and posttest, and no significant interaction between groups and time.

Hypothesis H₀₄ was accepted. Students receiving computer

assisted instruction in problem solving, the selection and application of appropriate knowledge, skills and techniques in solving problems, did not show significantly greater gains on a quantitative measure of problem solving than students receiving instruction with conventional methods.

Table 4.5

HYPOTHESIS 4- REPEATED MEASURES ANALYSIS OF VARIANCE ON THE NON-COMPUTER, COMPUTER, PRETEST, AND POSTTEST SUBTEST PROBLEM SOLVING SCORES GROUP EFFECT, TIME EFFECT, INTERACTION EFFECT

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
<u>Between Subjects</u>					
Group	1.183	1	1.183	0.012	0.914
ERROR	4409.785	44	100.222		
<u>Within Subjects</u>					
Time	156.687	1	156.687	1.741	0.194
Group*Time	156.687	1	156.687	1.741	0.194
ERROR	3960.280	44	90.006		

* Significant at $p < .05$

Other findings.

A repeated measures analysis of variance was done on student performance on the first and second semester exams. The analysis was done to determine if there was a difference in the performance of the non-computer and computer groups on the district city-wide exam. The repeated measures analysis of variance for exam scores looked at main effects for groups (computer vs. non-computer), time (pretest vs. posttest), and the interaction of group and time.

For the dependent variable exam scores, the analysis of variance indicated effects for group ($E(1,44) = 1.193, p < 0.281$), time ($E(1,44) = 136.776, p < .001$) and the interaction of group and time ($E(1,44) = .004, p < .952$) (see Table 4.6). The repeated measures analysis of variance for exams indicated there was no difference between computer and non-computer groups, a significant difference in pretest and posttest, and no significant interaction between group and time. There was no significant difference in the performance of the non-computer and computer groups on the district city-wide exams.

Table 4.6

OTHER FINDINGS- REPEATED MEASURES ANALYSIS OF VARIANCE ON
THE NON-COMPUTER, COMPUTER, FIRST SEMESTER AND SECOND
SEMESTER EXAM SCORES GROUP EFFECT, TIME EFFECT, INTERACTION
EFFECT

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
<u>Between Subjects</u>					
Group	381.926	1	381.926	1.193	0.281
ERROR	14091.476	44	320.261		
<u>Within Subjects</u>					
Time	14553.606	1	14553.606	136.776	0.000*
Group*Time	0.389	1	0.389	0.004	0.952
ERROR	4681.796	44	106.404		

* Significant at $p < .05$

Chapter 5

Summary, Conclusions, and Recommendations

Introduction

This study examined instructional techniques employed in the teaching of mathematics to low achieving mathematic students. The effect of computer assisted instruction in improving mathematics performance of low achieving 9th grade students was investigated. This chapter interprets the data collected in the study with summaries presented, conclusions stated, implications discussed, and future research suggested.

Summary

Purpose. The empirical data collected on CAI research by Burns and Bozeman (1981), Ragosta, Holland, and Jamison (1982), Kulik, Bangert, and Williams (1983) and Kinnaman (1990) concluded that the use of computer technology produced positive results in the classroom. When computers are used as a supplement to regular classroom instruction students learn more, respond positively to the instruction, and exhibit no significant attitude change toward subject matter. Researchers comparing computer assisted

instruction with conventional classroom instruction have reported that well-designed CAI can be more effective than conventional instruction. While findings to date are positive, they are inconclusive. The purpose of this study was to determine whether computer assisted instruction of mathematics produced significantly greater improvement in mathematics performance of low achieving ninth grade pupils than teaching mathematics skills without computer assisted instruction.

Review of the Literature. Suppes and Morningstar (1969) measured CAI drill and practice by standardized achievement tests and concluded intensive effort by the classroom teacher was just as effective as drill and practice on the computer. The computer saved time and did not require help from the teacher. Findings in Vinsonhaler and Bass's (1972) study concluded CAI was significantly more effective than traditional instruction. CAI drill and practice used as a supplement to conventional instruction was found to be effective in increasing the mathematic achievement of high and low achieving elementary and secondary students (Burns and Bozeman, 1981). Average level students showed no significant gain.

Conclusions of the early studies supported the effectiveness of CAI at the elementary level when used to supplement the conventional instruction. Research findings supported CAI's effectiveness for slower students in improving student achievement and savings in student study time.

While CAI research findings generally support the effectiveness of CAI, they are not conclusive. As Gourgey's (1987), Jamison, Suppes, and Well's (1974), and Gilman and Brantley's (1988) studies concluded no significant achievement gains were observed when comparing CAI with other alternative instructional techniques, they suggested that instructional outcomes were significantly affected by a variety of variables. The quality and relevance of software, randomization of students and the context in which the CAI was managed affected outcomes.

Research reported in the early 1980's on the effects of CAI in teaching mathematics, concluded that CBI raised student achievement from the 50th to the 60th percentile (Hartley,1977). The more recent research findings of Suydam (1986) concluded that CAI tutorials produced higher achievement gains than did

conventional instruction, eight of twelve studies reported no significant achievement gains between computer and non-computer groups using drill and practice, games were reinforcing and motivating serving as extrinsic reinforcers with college students using the games to problem solve while only one half of the eighth graders viewed the games in the problem solving context. Suydam (1986) suggested that with more research in the use of computers in mathematics, we should acquire greater detailed data on how to use computers more effectively. In light of the relationship between computer assisted instruction and its influence on the mathematics achievement of low achieving students, the need to evaluate its effectiveness in developing opportunities for student remediation and for increasing the understanding of computers in improving student mathematics achievement was evident.

Methodology. The sample consisted of four classes (N=46) of 9th graders who scored at the 30th percentile or lower on the ITBS as 8th graders. Two classes were taught augmented with CAI, and two classes were taught without CAI. CAI teachers selected

commercially produced software providing for drill and practice, simulation, and games to teach the mathematical skills of computation, concepts, and problem solving. All teachers used a structured lesson model format with appropriate models and examples provided for the skill taught. Teachers checked for understanding and provided for independent practice activities. Each teacher had a full sized classroom. CAI teachers taught in the mathematics computer lab with 16 Apple IIe microcomputers. Comparison groups were taught at alternating periods third through sixth to control for differences of instructional time of day.

Mathematics subtests of the ITBS and TAP for computation, concepts, and problem solving were administered to all students as pretest and posttest measures of achievement. A repeated measures analysis of variance was used to analyze data.

Major Findings.

For all four hypotheses, the analysis was conducted as a two-step process. The first step for each hypothesis was to test the overall null hypothesis of no difference in the means for the different groups. If statistical difference was found between the

computer vs. non-computer groups, the second step of the analysis required follow-up tests to be conducted to explain group differences. Findings for each hypothesis are reported as follows:

1. For the dependent variable total math score, the analysis of variance indicated effects for group ($F(1,44) = 4.924, p < .05$, time ($F(1,44) = 53.941, p < .001$, and the interaction of group and time ($F(1,44) = 6.451, p < .02$). The repeated measures analysis of variance results for total math, indicated there was some difference between computer and non-computer groups, there was a difference between pretest and posttest, and there was an interaction between groups and time. Post-hoc comparison data based on the Tukey test revealed the following. The non-computer and the computer groups were equal at the start of the study. Posttest comparisons of the non-computer to the computer group indicated no difference. Non-computer group gains from pretest to posttest were not significant. Computer group gains from pretest to posttest indicated significant score growth. Post hoc comparison data indicated that only the computer group gained.

2. For the dependent variable computation math score, the

analysis of variance indicated effects for group ($E(1,44) = 3.115, p < .085$), time ($E(1,44) = 57.817, p < .001$), and the interaction of group and time ($E(1,44) = 2.108, p < .154$). The repeated analysis of variance results for computation indicated there was no difference between computer and non-computer groups, there was a significant gain from pretest to posttest. However, there was no significant interaction between groups and time. Students receiving computer assisted instruction in computation with numbers of mathematics did not show significantly greater gains on a quantitative measure of computation than students receiving instruction with conventional teaching methods.

3. For the dependent variable concepts, the analysis of variance indicated effects for group ($E(1,44) = 2.385, p < .130$), time ($E(1,44) = 3.965, p < .053$), and the interaction of group and time ($E(1,44) = 3.688, p < .061$). The repeated measures analysis of variance results for concepts indicated there was no difference between computer and non-computer groups, no difference in pretest and posttest and no significant interaction between groups and time.

4. For the dependent variable problem solving, the analysis of

variance indicated effects for group ($E(1,44) = .012, p < .914$), time ($E(1,44) = 1.741, p < .194$), and the interaction of group and time ($E(1,44) = 1.741, p < .194$). The repeated measures analysis of variance results for problem solving indicated there was no difference between computer and non-computer groups, no difference in pretest and posttest, and no significant interaction between groups and time. For problem solving, no significant difference in achievement gains were found between students receiving computer assisted instruction and those not receiving CAI.

5. For the dependent variable semester exam scores, the analysis of variance indicated effects for group ($E(1,44) = 1.193, p < 0.281$), time ($E(1,44) = 136.776, p < .001$) and the interaction of group and time ($E(1,44) = .004, p < .952$). The repeated measures analysis of variance for exams indicated there was no difference between computer and non-computer groups, a significant difference in pretest and posttest, and no significant interaction between group and time. There was no significant difference in the performance of the non-computer and computer groups on the district city-wide exams.

Conclusions

From the analysis of results, major findings led to the following conclusions:

1. Student use of computer assisted instruction to improve total Mathematics skills of low achieving 9th grade students produced results that were greater by statistical significance at $p < .05$ than those produced by conventional instruction. Students receiving computer assisted instruction gained 17.857 points from pretest to posttest, increasing national percentile scores from a group mean rank of 11th percentile to the 30th percentile.
2. When subtest computation was measured, students receiving CAI produced no significant difference in achievement than students receiving conventional teaching methods.
3. For subtest concepts, achievement results for CAI students were not significantly different than students receiving conventional teaching methods.
4. In the subtest skill area of problem solving, there were no significant achievement gains for the computer group or the non-computer group.

5. Semester exams produced no significant difference in performance of the computer and the non-computer groups.

Discussion

With the main effect by group, main effect by time, and the interaction effect of this study being significant at the $p < .05$ for total math score, there was an indication of difference between the non-computer and computer groups. The first step in the repeated measures analysis of variance answered the question, did the computer assisted instructed students perform differently than the non computer students. All three tests indicated there was a significant difference. Interaction effect group and time compared the four means of group non-computer and computer and of time pretest and posttest. Once they interacted, they could not be looked at independently. They were tied together, and the reported significance indicated some complexity between group and time.

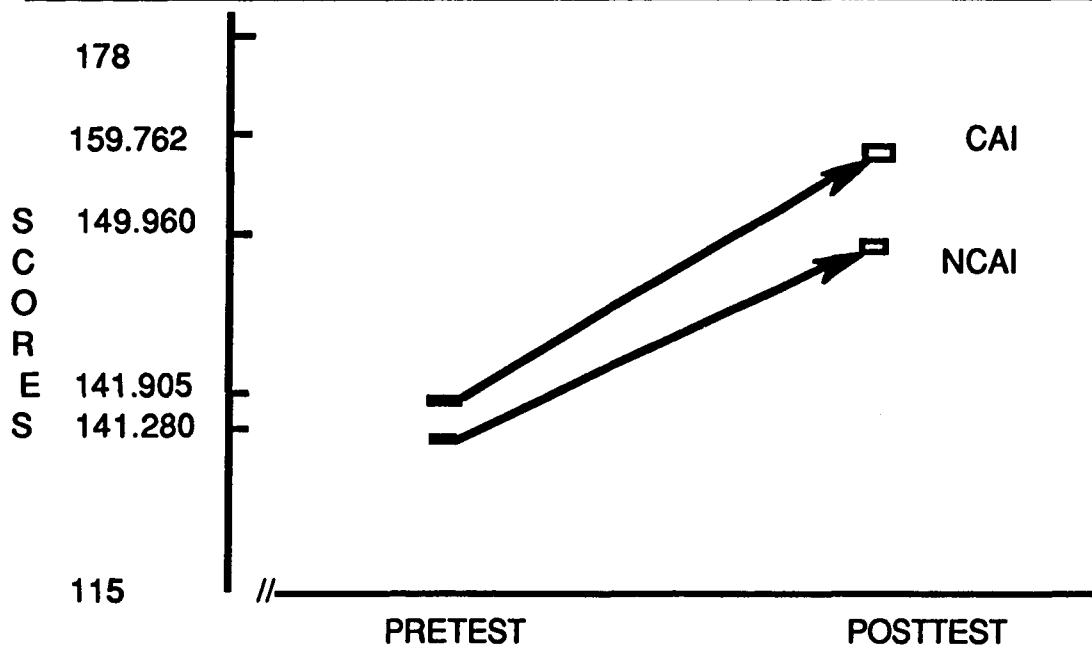
Post hoc tests established that the non-computer groups (mean 141.280) and the computer groups (mean 141.905) started on an equal basis. Post hoc comparison data revealed that the non-computer group growth was not significant, and that the computer

group had a significant difference in growth from pretest to posttest. Only the computer group had significant achievement gains. The statistical data reported supports the findings of Kulik's 1983 synthesis of recent computer assisted instruction studies which concluded that computer assisted instruction produced stronger effects on student achievement than conventional instruction.

Although the post hoc comparison Tukey test determined the mean difference of 9.802 to be less than the required 17.45 for significance, there was a definite pattern developing suggesting that the computer group was performing better than the non-computer group.

On the following page, Figure 2 presents the pattern.

Figure 2. Interaction effect group and time comparison of the four means.



While findings for total math supported a favorable direction for the computer group with an average achievement gain of 9.802, none of the subskill's interaction findings reported any significance of the computer group or the non-computer group. In this study, a number of diverse indices of total math achievement were used: (a) success in problem solving, (b) success in computation, and (c) success in concepts. The program was not focused in one area but

several areas. Small improvements in achievement gains in the individual sub-skills areas could add up to produce significant effects in total math scores and did. The cumulative effect of the sub components did show the advantage of computer instruction.

The data indicated gains in the non-computer group from 141.280 to 149.960. This represents students scoring at the 11th percentile rising to the 17th percentile. Although the gain was not statistically significant, it does indicate a growth trend of the non-computer group. Gains in the computer group, however, were statistically significant increasing from a pretest mean of 141.905 to a posttest mean of 159.762. This gain means the computer group improved from the 11th percentile to the 30th percentile.

The findings have practical implications for the educator. Given the demands placed on superintendents to improve student mathematics scores on national tests by a variety of constituencies, superintendents can draw support from the empirical data to request funds from school boards to offer such instruction. Teachers and principals can use these data to help improve classroom instruction in mathematics.

Gains like this have educational implications for students. Students receiving computer assisted instruction may improve deficits in mathematics performance. With the 25th percentile on the ITBS indicating potential student failure on the State literacy passport test, study gains of 13 percentile points can move students to acceptable performance levels. Study gains suggest that students receiving computer assisted instruction to remediate mathematics deficiencies would receive greater performance benefits than non-computer students. The student aspiring to attend college may benefit from computer assisted instruction in enhancing mathematics skills. As observed, there was a pattern of growth improvement in the non-computer group where teachers used conventional instruction (directed teaching) and significant growth was observed where teachers used computers to augment conventional instruction. Computer assisted instruction could move all students to improved performance levels.

Several factors may have influenced study results. Jamison, Suppes, and Wells (1974), Gourney (1987), and Gilman and Brantley (1988) suggested that instructional outcomes were significantly

affected by a variety of variables which included the quality and relevance of software, randomization of students and the context of CAI management. Although the software was reviewed by study teachers for curriculum match and relevance, it was the first time the teachers had used and managed the software. While the Minnesota Educational Computing Consortium (MECC), the High School Math Competency Series, and Barnum, (1987) software were matched to the curriculum and assessed to be age appropriate, student comments reflected some programs to be childish. This appeared to be especially true for problem solving software.

Another factor which may have influenced study results was associated with the games software. As Suydam (1986) concluded that while games were reinforcing and motivating serving as extrinsic reinforcers with college students using the games to problem solve only one half of the 8th graders viewed the games in the problem solving context. Study teachers commented that students were excited to use the computers and were motivated to use them. However, they observed that many students worked through the problem solving games software for the expressed

purpose of being able to play the game. The student's behavior suggest that the games software was not viewed in the problem solving context.

Since problem solving as a mathematical skill was primarily presented within the context of games, this variable could have impacted on study results. Most of the skill areas had two problem solving games. Students that had finished an assignment or wanted to review a skill were encouraged to use the software programs to reinforce the skill learned. Study teachers commented that for some students the objective was to play the game. Although teachers attempted to control this behavior by awarding a daily score on the software program, some student's continued to solve the problems by random trial and error. Seldom did students use a wide variety of problem solving strategies to complete the task.

Empirical data collected on CAI research by Burns and Bozeman (1981), Ragosta, Holland, and Jamison (1982), Kulik, Bangert, and Williams (1983), and Kinnaman (1990) concluded that students learn more when CAI was used as a supplement to conventional classroom instruction. For mathematics, Gourgey (1987) suggested that formal

instruction coordinated with drill and practice was essential for the development of conceptual skills and for the development of the rote skills of computation. For concepts and computation, a formal explanation of the concepts and procedures appears to influence student understanding. CAI groups received formal instruction on the concepts and procedures. There were no significant achievement gains for computation and concepts. The computer served as the primary source for dependent and independent practice of the concepts and procedures.

Informal observations by study teachers offer an explanation for insignificant gains. For the High School Math Competency Series software, students responded to problems by selecting one of four multiple choice answers. Correct or incorrect response was indicated on the computer monitor. Students were allowed a second opportunity to answer the problem. If the selection was wrong a second time, the program advanced to the next problem. There was no explanation given in the program as to why a student's answer was incorrect. Students appeared to be guessing at answers on the computer and in some cases were observed typing the wrong answer

on the computer several times suggesting a lack of understanding of the concepts tested. The Barnum, (1987) software did not provide an explanation for incorrect student responses. The race car slowed down with an incorrect answer and accelerated with correct responses.

The MECC software provided 2 to 5 answers to a problem but only one opportunity to answer. Program feedback to students was provided by statements, yes you are correct or no you are wrong-try again. If a student was incorrect, the MECC software programs gave an explanation to the students of why their selection was wrong. Steps to successfully solve the problem were listed. Although MECC software programs were used in most of the skill areas, they were not used in the areas of geometry, measurement, probability, intergers and algebra, multiplication and division of fractions, substracting decimals and the application of multiplying and dividing whole numbers and decimals. The High School Math Competency Series was the software program used in these areas. The lack of software selection that provided for explanation of incorrect student responses throughout all skill areas may have

influenced study results.

Study teachers commented that the students had some difficulty in reading the computer programs. Although the programs were matched for curriculum content and age appropriateness, computer teachers expressed that some students had difficulty comprehending the programs. Study teachers stated this was especially true for word problems. Even with computer instruction programmed at several levels of difficulty, teachers commented on the observed and expressed frustration of some students. One instructor commented that one student refused to attempt any of the word problems in the programs, and it was only after continued reinforcement by the teacher that the student made an attempt. Each of the computer teachers observed students guessing at answers. When questioned by teachers, students could not explain their answers. Some students requested teacher assistance in reading the problems. To some extent, study results could have been influenced by student reading level.

The findings and subsequent conclusions stated in this study should be generalized only to sample populations studied under

similar conditions. The researcher concluded that computer assisted instruction was significant in improving mathematics performance of low achieving 9th grade students. Although students receiving CAI did not show significant improvement in the mathematical subskills of computation, concepts, and problem solving when compared to students receiving non-computer instruction, the cumulative treatment effect (CAI) did result in significant growth in total mathematics performance.

Recommendations for Future Research

As a result of the analysis of the results of this study, the following recommendations are suggested to provide additional and more conclusive information about the relative effectiveness of computer assisted instruction in improving mathematics performance of low achieving students:

1. A study which would provide explanatory software for each of the subskill areas of computation, concepts, and problem solving could be compared with this study .
2. Research and development of software that has the best instructional design for student achievement level and the difficulty

level of the tasks is essential. Educators must investigate software programs to determine the most appropriate instructional design.

3. A longitudinal study of the effects of computer assisted instruction in improving mathematic skills of low achieving students would address the novelty effects which decline over years and would help to determine the long term effects of computer assisted instruction.

4. Research to investigate the use of special computer features to determine the best conditions for learning would be beneficial in exploring the potential of computers in improving and in changing the processes of teaching mathematics.

5. A study to investigate the use of computers to emphasize mathematical procedural knowledge, how the problem is solved, instead of factual knowledge would be beneficial in determining how the computer can enhance and change the way students learn. A study of the effectiveness of computer laboratories that simulate real mathematical situations with real facts could provide data to improve computer instruction.

6. Research to investigate the most effective use and types of

computer software to improve the mathematic skill areas of computation, concepts, and problem solving is needed. Studies could investigate whether certain types of computer software produce better performance results than others for specific skill areas.

7. A study on investigating the quality standards for the evaluation of computer software is essential. The effectiveness of microcomputers to improve student performance needs to be evaluated using the best quality software.

APPENDIX

Letter to Parent of Student

Consent Form

Dear Parent:

I am a doctoral student at the College of William and Mary. In partial fulfillment of the requirements of the doctoral program, I am conducting research to determine whether computer assisted instruction makes a difference in mathematics performance of low achieving ninth grade students. The research is being conducted with students of Bethel High School in the Hampton City Public School Division and has been approved by the research review boards of Hampton City Public Schools and the College of William and Mary.

I am asking for your permission to allow your son _____ to help with my study. Before you decide you should know the following facts:

.This is completely voluntary. No one will hold it against your son if you decide not to allow him to participate.

.If you allow him to participate, his name will not appear on any forms.

.He will be randomly assigned to an instructional group using computers or an instructional group not using computers. (Computer assisted instruction) or (teacher directed instruction).

.The study will not be of detriment to your son but could be of benefit.

.The length of time of the study is two semesters/one school year.

.To protect individual confidentiality all data will be analyzed and reported by group.

.You may have a copy of the final report of the study if you like.

If you have any questions or wish a fuller explanation, please feel free to contact Mr. Thomas E. Bailey, (804) 825-4755 or Dr. William G. Bullock, Jr. (804) 221-2325. Also, you may contact Dr.

Thomas Ward, chairman, School of Education Human Subjects Review Committee, if you have any complaints (804) 221-2358.

If you decide to allow your son to join in the study, please put an X on the line in front of the sentence below and follow the rest of the directions.

YES, I give my permission for my son _____ to participate in your study.

(PRINT your name here)

(SIGN your name here)

I feel that it is important that you discuss this with you son. He needs to understand that he can opt out of the study at anytime without penalty and he needs to agree to participate. Would you please explain this and have you son sign below.

(STUDENT'S assent)

(DATE)

Thank you very much,

Thomas E. Bailey
Principal

Please Return This Consent Form No Later Than Tuesday, August 28, 1990. A Self Addressed Envelope Is Provided.

REFERENCES

References

- Barnum, D. (1987). Quarter Mile [Computer Program]. Oakland, Ca: Barnum Software Co.
- Bear, G. G. (1984). Microcomputers and school effectiveness. Educational Technology, 11-15.
- Becker, H. J. (1987, April). The impact of computer use on children's learning: What research has shown and what it has not. A paper presented at the Annual Meeting of the American Educational Research Association, Washington, D.C.
- Bray, J. H. and Maxwell, S. E., (1985). Multivariate Analysis of Variance. Beverly Hills, California: Sage Publications, Inc.
- Burns, P. K. and Bozeman, W. C. (1981). Computer assisted instruction and mathematics achievement: Is there a relationship? Educational Technology, 21, 32-39.
- Cannaday, B. K. (1990). A comparative study of the relative effectiveness of computer assisted instruction, cooperative learning and teacher directed instruction on improving mathematic performance of low achieving students. Unpublished doctoral dissertation, Virginia Polytechnic Institute and State University, Virginia.
- Circus Math. (1984) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.
- Coburn, P., Kelman, P., Roberts, N., Snyder, T., Watt, D., and Weiner, (1982). Practical Guide to computers in education. Reading, Massachusetts: Addison-Wesley Publishing Company.
- Conquering Decimals. (1988) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.

- Conquering Fractions. (1988) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.
- Conquering Percents. (1989) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.
- Conquering Ratios and Proportions. (1989) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.
- Conquering Whole Numbers. (1987) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.
- Coordinate Math. (1987) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.
- Cook, T. D. and Campbell, D. T. (1979). Quasi-experimentation: Design and analysis issues for field settings. Boston: Houghton Mifflin Company.
- Cox, D. (1980). Early adolescent use of selected problem solving skills using microcomputers. Doctoral Dissertation, The University of Michigan.
- Decimal Concepts. (1988) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.
- Ebel, R. L. (1982). Three Radical Proposals for strengthening education. Phi Delta Kappan, 375-380.
- Edwards, J., Norton, S., Taylor, S., Weiss, M., and VanDusseldorp, R. (1975). How effective is CAI? A review of the research. Educational Leadership, 33, 147-153.
- Fraction Munchers. (1986) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.

- Gilman, D. A. and Brantley, T. (1988). The effects of computer-assisted instruction on achievement, problem-solving skills, computer skills, and attitude. Washington, DC:US. Department of Education, National Institute of Education. (ERIC Document Reproduction Service No. ED. 302232).
- Glidden, W. C., Harrold, J. R., Hodges, R. A., and Kunec, J. (1984). The Coast Guard's CAI approach to basic math and reading skills. Washington DC:US. Department of Education, National Institute of Education. (ERIC Document Reproduction Services No. ED. 249-365).
- Gourgey, A. F. (1987). Coordination of instruction and reinforcement as enhancers of the effectiveness of computer-assisted instruction. Journal Educational Computing Research, 3, 219-230.
- Hartley, S. S. (1978). Meta-analysis of the effects of individually paced instruction in mathematics (Doctoral dissertation, University of Colorado, 1977). Dissertation Abstracts International, 38 (7-A), 4003 (University Microfilms No. 77-29, 926).
- Hawley, D. E. (1986). The Costs, Effects, and Utility of Microcomputer Assisted Instruction in a Rural School Division in Canada. Dissertation Abstracts International, 46A, 3208.
- High School Math Competency Series. (1987) [Computer Program]. Micro Computers Workshop Courseware. Fairfield, Ct.
- Hotard, S. R. and Cortey, M. J. (1988). Using computer assisted instruction to raise and predict achievement in Chapter I students. Washington, DC:US. Department of Education, National Institute of Education.(ERIC Document Reproduction Service No. ED 293104).

- Hunter, M., (1982). Mastery Teaching. El Segundo, California: TIP Publications
- Iowa Tests of Basic Skills, Level 14, Form G, Chicago, Ill.: Riverside Publishing Company, 1986
- Jamison, D., Suppes, P., and Wells, S. (1974). The effectiveness of alternative instructional media: A survey. Review of Educational Research. 44, 1-67.
- Kinnaman, D. E. (1990, March). What's the research telling us? Classroom Computer Learning. 31-34.
- Kulik, J. A. (1983). Synthesis of Research on Computer- Based Instruction. Educational Leadership. 41, 19-21.
- Kulik, J. A. (1981), (April). Integrating findings from different levels of instruction. Paper presented at the American Educational Research Association, Los Angeles. (ERIC Document Reproduction Service No. ED 208040).
- Kulik, J. A., Bangert, R. L., and Williams, G. W. (1983). Effects of computer- based teaching on secondary school students. Journal of Educational Psychology. 75, 19-26.
- Kulik, J. A., Kulik, C. L. C., and Cohen, P. A. (1980). Effectiveness of computer-based college teaching. A meta-analysis of findings. Review of Educational Research. 50, 525-544.
- Lang, W. S., Branch, A., and Thigpen, S., (1987). Analysis of the effects of the computer enhanced classroom on the achievement of remedial high school math students. Washington, DC: U.S. Department of Education, National Institute of Education. (ERIC Document Reproduction Service No. ED 301600).

- McConnell, B. R. (1983). Evaluation of Computer assisted instruction in Math. Pasco School District. Final Report. Washington, DC: U.S. Department of Education, National Institute of Education. (ERIC Document Reproduction Service No. ED 235959).
- McMillan, J. H., and Schumacher, S. (1989). Research In Education (2nd ed.). Illinois: Scott, Foresman, and Company.
- Norusis, M. J. (1985). SPSSX Advanced Statistics Guide. New York: McGraw-Hill Book Company.
- Number Munchers. (1986) [Computer Program]. Minnesota Educational Computing Corporation. Minneapolis, Mn.
- Ragosta, M., Holland, P. W., and Jamison, D. T. (1982). Computer assisted instruction and compensatory education: The ETS/LAUSD Study. Washington, DC:NIE.
- Signer, B. (1982). A formative and summative evaluation of computer integrated instruction. Paper presented at the CBE Research Conference.
- Smith, I. D. (1973). Impact of computer-assisted instruction on student attitudes. Journal of Educational Psychology. 64, 366-372.
- Suppes, P. and Morningstar, M. (1969). Computer-assisted instruction. Science, 166, 343-350.
- Suydam, Marilyn N. (1986). An overview of research: computers in mathematics education. K-12. Washington, DC: U.S. Department of Education, National Institute of Education, (ERIC Document Reproduction Service No. ED 276629).
- Tests of Achievement and Proficiency. Level 15, Form H, Chicago, Ill.: Riverside Publishing Company, 1987.

Vinsonhaler, J. F. and Bass, R. K. (1972). A summary of ten major studies on CAI drill and practice. Educational Technology, 12, 29-32.

Wilkinson, L. (1989). SYSTAT: The System for Statistics. Illinois: SYSTAT, Inc.

VITA

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