EVALUATION OF COMPUTER ASSISTED INSTRUCTION
1989 - 1990

by

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PREFACE

This study examined the effectiveness of the Computer Curriculum Corporation (CCC) Computer Assisted Instruction (CAI) system at Robert Fulton Middle School in Milwaukee, WI for the 1989-1990 school year. Analysis of the problem produced research questions. The research questions relevant to this study were:

Is supplementary CAI more effective than regular classroom instruction in raising math achievment?

What are students' and teachers' attitudes towards CAI?

Does CAI cost more than regular instruction, and if so, can the cost be justified?

In order to answer the research questions, five groups of eighth grade students were employed -- four receiving supplemental CAI, and one receiving regular instruction alone. The research design employed here can be described as a pre-test/post-test control group design. In regard to this design, data related to grade level equivalency was collected utilizing the Math Acheivment Test, as well as raw score and Normal Curve Equivalency (NCE) scores on four mathematics strands of Iowa Test of Basic Skills (ITBS). When these scores were established Analysis of Covariance (ANCOVA) was applied to test for significance of F. In addition, questionaire data was collected from study group students and their teachers to determine students' and teachers' attitudes towards CAI. Finally, a cost analysis was calculated based on per-pupil cost for regular instruction versus supplementary CAI.

I would like to express my appreciation to the members of my thesis committee for their advice and support during the writing of this paper. Dr. John J. Augenstein, Chairman of the committee, encouraged my ideas for this study from the beginning. Dr. Terrence D. Wong, and Dr. Michael D. Kurimay, S.J. also have been excellent resources during the writing of this paper. All, in their own ways, have contributed to this project and to my personal development.

I would also like to express my appreciation to other people who have helped me in the conduct of this study. Saul Reeves Jr., and the administration of Robert Fulton Middle School, encouraged this research. Dr. Barbara S. Monfils, of the Marquette Computer Services Center, introduced me to the VAX and SPSS systems, and was a great help in teaching me to run ANCOVA on the research data. Dr. Naveen Bansal, of the Marquette Math and Science Department, helped interpret ANCOVA data. I also owe thanks to the students and faculty of Robert Fulton Middle School who participated in this study.

Special thanks goes to many family members and friends who have encouraged and supported me during the course of this study. My most important acknowledgement, however, goes to my parents, who instilled in me a love for life-long learning. To my mother, who nutured a respect for thoroughness and detail, and to my father, whose uncanny ability to observe the obvious imparted in me the desire to be concise. Without their loving support this paper would not have been completed.

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CHAPTER I

INTRODUCTION

Computer assisted instruction (CAI) is a process by which students learn through comprehensive interaction with a computer. Instructional materials are stored in a computer hard drive (Microserver) and students interact, individually, with these materials at a computer terminal. This study was limited to CAI lessons in Math Concepts and Skills (MCS) developed by Computer Curriculum Corporation (CCC) of Palo Alto, California. The instruction combined individualized practice in arithmetic calculations and highly visual exercises designed to demonstrate mathematical concepts and sharpen problem-solving skills. The Microserver instructional system individualized each student's path through the course. It recorded and evaluated the sequence of the student's response and provided the student with new materials, tutorials, additional practice in the current skills, or practice with prerequisite skills, depending on the students performance. Students who did well moved rapidly through the course, and students whose performance indicated difficulty received additional instruction varied according to their demonstrated need. Each student's performance was summarized in detailed course reports for teachers. The reports included recent and cumulative scores, grade-level equivalents for each skill, and identification of any particular skills the student may have been having difficulty mastering.

First, in regard to the development of this study, a statement of the problem is described followed by a discussion of the significance and evolution of the problem. Next, a review and summary of the literature is presented that generalizes the findings of CAI research literature pertinent to this study. Following that is a discussion of the subjects, basic research design, as well as an explanation of the testing measures to be used.

Statement of the Problem

This study will investigate the effectiveness of the CCC CAI system at Robert Fulton Middle School in Milwaukee, WI for the 1989-1990 school year. Analysis of the problem produces research questions. The research questions relevant to this study are:

Is supplementary CAI more effective than regular classroom instruction in raising math achievment?

Does CAI have a positive effect on students' and teachers' attitudes?

Does CAI cost more than regular instruction, and if so, can the cost be justified?

The writer believes objective information regarding these questions would be useful to the purpose of planning and directing the further progress of CAI in public and private education.

Significance of the Problem

First, research must be ongoing because CAI software is continuously being updated. Although most research reported benefits gained by students who used CAI, no guarantee could be made as to the benefit(s) of updated versions of CAI, nor could benefits gained be attributed to the same skills as addressed by the older software.

Second, this study utilizes a control group. The author believes this procedure will insure that test-score gains are not due to influences other than CAI.

Third, this study shows that CAI gains are significant in low-achieving urban students. The majority of research studies conducted on CAI conclude that achievment is higher for low-ability students than for other groups of learners. This study utilizes groups of low achieving students in the CCC CAI setting.

Fourth, this study shows through survey results given that students' attitudes towards learning is enhanced with the use of the computer as an educational tool, and, also through survey results, that teachers' attitudes towards CAI are positive. Ragosta (1982), Fisher (1983), Kulik (1984), Way (1984), and Payne (1986) found more positive attitudes towards learning in CAI students. Guerrero and Swan reported positive attitudes towards CAI from interviews they conducted with teachers and students. In general, there seems to be a direct correlation between the use of CAI, and student attitude. This study quantifies the results of achievment and attitude in students and teachers through the use of surveys.

Fifth, this study demonstrates the cost effectiveness of CAI. Lavin and Sanders (1982), Pressman and Rosenbloom (1983-84), and Chamberlain (1986) report on the initial cost of implementing CAI. In each case it was found that CAI costs more per pupil than regular instruction. This study shows that over a three year period, with product support and update, CAI can be cost effective.

Purpose

The problem here chosen for study can be more completely understood in the light of current developments in the fields of technology and education, and with regard to the natural shifts in emphasis that occur in the professional and non-professional communities related to education. Coupled with Beckers' report on the state of CAI research is the push to implement the new National Council of Teachers of Mathematics (NCTM) standards, which advocate the use of manipulatives, cooperative learning, and the development of Higher Order Thinking Skills (HOTS). In general, there seems to be a perceived notion that more human interaction equals better understanding, and that CAI addresses little more than drill and practice. And there is research that suggests CAI has little, novel, or no affect on achievment or attitude (Ngaiyaye and Vanderploge, 1986).

These developments may have a negative and incongruous effect on a school district's decision to invest, or not, in technology, at a time when technology is advancing at an exponential rate, and when the United States' position as a world power is being challenged, especially on the financial front. It was this writers experience that an inner-city CAI lab was going to be eliminated on the basis of a Board decision to spend money elsewhere, and because student achievment was not at a level consistent with other schools in the system. Also, there was a request that CAI lab teachers remove their students from computers during lab time so there could be small-group interaction. This lack of communication and misunderstanding may often affect student instruction negatively.

Ironically, but not less significantly, at the bottom of the political hierarchy, are the students, who, seem to be totally engrossed with electronically processed information. On April 1, 1991, the Milwaukee Journal ran a front page story on a young man who "At 19 . . . has a job at computer giant Cray Research in Chippewa Falls, a drawer full of math and science prizes, and a D average at the high school from which he did not graduate". This is an extreme example of a growing phenomenon. Students seem to be losing the patience needed to learn using the traditional paper and pencil method, and are learning to like the speed and efficiency technology delivers.

Relevant to this discussion is a quote from comments made on June 21, 1989 at the National Educational Computing Conference:

> "Education faces a critical crisis. Old solutions will not solve today's problems and have little relevance to tomorrow's opportunities. Yet this current crisis and the desire to restructure education offers us a 'window of opportunity.' It is time to create a new, national infrastructure to make computing available to all" (Molnar,1989).

The purpose of this study is not in any way to downplay the importance of traditional methods of instruction, but to stress the importance of integrating technolgy in order to optimize the curriculum. The purpose of this study, therefore, is to codify previous research, provide further proof of the effectiveness of, and expedite the use of the computer as an educational tool.

CHAPTER II

REVIEW OF THE LITERATURE

Evolution and Plan of the Review

This review focuses primarily on the use of CAI in grades K-12, and reports research on the relative merits of traditional instruction and CAI in promoting student achievment. Secondary issues including cost and attitude are also addressed. The review is the result of an ERIC computer search using the key phrases "CAI", and "Schools", and other related research. Of 137 possible studies generated by ERIC and found otherwise, 17 were found to be of potential relevance. Of these 17 studies, five were literature reviews in and of themselves, and twelve were independent studies.

The plan of this review is, first, to present a review of the reviews. The major link between these reviews is the fact that they report on achievment gains relative to CAI. There is no consideration given by the review researchers as to the consistency of analysis type reported on. For example, control group versus experimental group, box-score, and meta-analysis, are combined in a review of the literature style, and reported on in a quantitative fashion. Issues related to attitude and cost are embedded in research contained within the reviews, so to link these issues together would be to entangle a review of research within another. Also, these studies are not completely independent, and tend to build upon one another to an unknown degree, as do all of the reviews in this section. Therefore, these studies will be presented chronologically.

The remaining studies are individual, of various types, e.g., longitudinal, interview, ANOVA, ANCOVA, but report primarily on CAI achievment. Again, issues related to attitude and cost are embedded within the research. In order to maintain consistency these studies are presented chronologically as individual studies. Three studies found report negative results. These are presented last and again in chronological order.

Following the reports of studies, I summarize the findings related to achievment, attitude, and cost in a quantitative manner, and discuss the findings relative to this study. The conclusion presents generalizations pertinent to this study and identifies the research niche in which this study will fit.

Reviews of Reviews

The first study in this section is a review of research compiled by Edwards et al. (1975). Among the findings is that when CAI is provided as a supplement to traditional instruction, CAI is more effective than normal instruction alone. The Suppes (1972) study was the most remarkable with gains of of over two grade levels in computational ability in one year.

All studies showed that it took less time for students to learn through CAI than through other methods. Lunetta and Blick (1973) compared computer simulation of high school physics experiments with traditional laboratory experiments and found that CAI students learned more in one eighth the time.

With regard to effectiveness according to ability level, Martin (1973) and Suppes found CAI drill and practice in arithmetic to be relatively more effective for low ability students than for average or high ability students.

The second review of reviews focuses on students' attitudes towards CAI. Lawton and Gerschner (1982), in their review of literature on attitudes towards CAI, inlude samples comprised of ERIC referenced articles written between 1976 and 1982. Among their citations is a reference to the Burns and Bozeman study, who wrote that no ultimate answer related to CAI effectiveness could be presented. However, the Clement (1981) research study repeatedly showed that children found computers to (a) have infinite patience, (b) never get tired, (c) never get frustrated or angry, (d) never forget to correct or praise, and (e) to individualize learning.

Other researchers noted that computers worked because (a) computers were impartial to ethnicity, (b) computers were great motivators, (c) computers were excellent for drill and practice, and (d) the teaching process was structured to teach children in small increments.

The third review of reviews is a study by Stennett (1983) which takes into account five detailed critical reviews of research and empirical research studies dating from 1966 to 1983. The five major reviews included are: Vinsonhaler and Bass (1972); Edwards, et al. (1975); Burns and Bozeman (1981); Kulik, J. et al. (1983); and Kulik, C.C. et al. (1984).

Vinsonhaler and Bass reviewed ten studies published between 1966 and 1970. Math and language arts CAI studies were used in grades one through six as a supplement to traditional instruction (TI) with standardized achievment tests as the outcome measures. Supplemental CAI was provided for five to fifteen minutes daily over periods ranging from three to ten months.

CAI students made greater achievment gains in math [.0 to .88 G.E. (grade equivalents)] and language arts (.1 to .4 G.E.) over students receiving only TI.

The Edwards study is a box-score type review covering 33 studies published between 1966 and 1973, and provides no information on the results of tests of statistical significance. Of 33 studies, ten compared CAI as a supplement to TI. Students receiving CAI gained more in achievment than students receiving only TI. Five of these studies involved CAI in arithmetic with students in grades two through six and three of the five studies were the same as those reported by Vinsonhaler and Bass. Two studies involving CAI for elementary arithmetic found relatively greater gains for low ability students.

The Burns and Bozeman study, a meta-analysis, covered 40 studies done before 1981, and concentrated on supplementary CAI in math for elementary and secondary students. An overall mean ES (Effect Size) of .40 (.25 or greater is considered to be of educational significance) was obtained, thus indicating an advantage for CAI supplemented math over TI. Supplementary CAI was found to be more effective at elementary than secondary levels. Also, there was some suggestion that boys may respond more favorably than girls.

The most often cited study covered by Stennett is a meta-analysis by Kulik, et al., which integrated the findings from 51 studies on CAI in grades six through twelve. All studies reviewed involved control groups. Forty-eight of the studies reported results from final examinations and in about 80% of these, CAI students outperformed students who recieved only TI. Of the 25 studies in which statistically significant differences were reported, 23 favored CAI students. The overall mean ES for all studies was .32. The tendency for lower ability students to profit more from CAI was apparent in the findings.

Also, in four studies CAI instructed students had more positive attitudes towards computers (mean ES = .61).

The 1984 Kulik meta-analysis covered 25 studies of CAI guided instruction for students in grades one through six. In every one of the 25 studies using student achievment as the outcome measure, students in CAI outperformed students receiving TI (mean ES = .48). In four studies the average ES was greater for low ability students.

Kulik generalized from this and other studies that CAI is increasingly effective as one goes from college to secondary to elementary levels. One rationale for this finding is that older students have less need of highly structured learning materials, immediate feedback and teacher control.

Stennett concluded from reviewing these five studies that CAI does improve student achievment, but that there are no clear answers as to which features of CAI are responsible for its beneficial efects.

The fourth review of the review studies is a meta-analysis which measured the effects of elementary school CAI. This study combined the work of 48 separate investigators (Niemic and Walberg, 1985). The studies were drawn from books, education and psychology journals, government documents and doctoral dissertations, and represent every area of the United States as well as several foreign countries. Documents covered the years 1968-1982.

The results of analysis of variance (ANOVA) at the various grade levels produced no clear pattern. However, when grade levels were collapsed into the broader categories of primary, intermediate, and upper, there was a clear indication of differential effect. CAI was found to be most effective in the primary grades. Effect sizes for the various grades were .81, .27, and .32 respectively.

Gender was found to be an important variable in achievment. Results of this synthesis of studies suggest that boys may actually learn more than girls. When effect sizes were analyzed separately by gender, elementary boys' achievment was approximately double that of girls' (boys = .45; girls = .22).

Lower achieving students scored significantly higher gains from exposure to CAI than other students. CAI gains appeared to be inversely related to prior achievment, with the drill and practice form of CAI producing the highest average effect sizes (.47).

Regarding achievment, Vickie S. Rupe (1986) referenced five studies in another synthesis of reviews. These studies were, again, reviews of literature in themselves. Reviews included are: Bracy (1982); Dence, (1980); Edwards, (1975); Forsman, (1982); and Fisher (1983).

Bracy reported generalizations based on the Kulik study, and studies by the Educational Testing Service (ETS). The ETS studies, which lasted four years, found CAI to be an effective learning aid over the long-term as well as the short-term period. Also, it was shown that CAI could be easily replicated.

The Dence study related the findings of 17 studies on CAI done in the 1970's. Findings show that the sciences are areas in which CAI was consistently effective (Koch, 1973; Magidson, 1978). Compared to traditional instruction, CAI resulted in equal or better performance gains (Magidson, 1978; Lewellen, 1971; Allen, 1972). Tsai and Pohl (1978) found that students who had both CAI and traditional instruction scored higher on final exams than did either group using separate treatments. Savings in learning time time were reported in studies by Allen (1972), and Bitzer and Alpert (1970).

Edwards reports that CAI mathematics drill-and-practice was most effective with low-ability students. Retention studies indicated retention of learning was equal to or less than learning obtained through traditional means, and studies measuring time-savings reported that it took less time for students to learn through CAI than through other methods.

Based on five different CAI research reviews, Fisher summarized the effects of CAI on learning. According to the reviews, CAI is most effective at raising achievment for low-achieving and high-achieving students. CAI is also consistently effective when integrated with classroom instruction, and when used in particular areas, especially science and math.

In addition to the effects of CAI on academic achievment, affective results were reported. These include positive student attitudes, improved attendance, increased motivation, and lengthened attention span.

Bracey also cited a study by Pressman and Rosenbloom (1983-84) that reported that the costs of a CAI system were becoming more affordable, and that cost-savings that would offset the expense of a CAI system would include the possibility of decreasing the dropout rates because of increased student interest and motivation.

Individual Studies

Hotard and Cortez (1981) studied Computer Curiculum Corporation (CCC) CAI as an enhancer of remediation in a Title I mathematics program for grades three through six. ANOVA summary tables illistrated that CAI added a significant standard score gain above and beyond that made by standard instruction. It was determined from examination of grade achievment gains and grade equivalent gains that CAI provided an important vehicle for learning arithmetic skills, and enhanced the process of remediation.

A longitudinal evaluation of CAI by Lavin and Sanders (1982) showed CAI drill and practice to be effective when it was used to supplement classroom instruction in the Chapter I program. During the 1979-1980 school year, it was found that the CAI treatment was superior to the non-CAI treatment for studies in mathematics. The program, structured to emphasize basic skills, was also cost effective. A low per student/per lesson cost, combined with the achievment gain demonstrated cost-effectiveness. Through a collaborative approach with system maintenance, technical assistance and other supportive organizational arrangements, individual school districts could access effective CAI services to augment instruction in compensatory programs which otherwise would be too expensive and difficult to maintain locally.

Ragosta, et al. (1982) discusses the results of a five year longitudinal study that evaluated the effectiveness, replicability, and costs of a Chapter I funded CCC CAI program. The mathematics, reading, and language skills curriculums proved to be effective in raising students scores not only on tests derived from the CAI curricula but on standardized tests as well. On standardized tests of mathematics computation, CAI students performed at the 64th percentile of their control groups at the end of one year, at the 71st percentile by the end of two years, and at the 76th percentile at the end of three years.

A greater sense of internal responsibility for success was found among CAI students. Prior to CAI implementation no differences were found between CAI and non-CAI means. Afterwards students in CAI had significantly greater means for self-responsibility. Furthermore, the difference seemed to widen with continued CAI exposure. It was generalized from the evaluation that computer use by educationally disadvantaged students may enhance self-responsibility for academic success.

A three year longitudinal evaluation of a supplementary Chapter I CAI program instituted by Metrics Associates, Inc. (1983) showed clear and significant effects attributable to the CAI treatment for reading and mathematics throughout the three year period. A quasi-experimental research design was utilized, with a comparison group. Evaluations conducted separately in each program showed the supplementary CAI treatment to have been more effective than were regular services alone.

It was reported that attempts at assembling a continuing group of students who had been participants in the program throughout its three year period were not successful. Only 52 students were found. Of these, 30 had pre- and post-test scores which allowed them to be included in the analysis for reading. In mathematics, there were even fewer students. After these small groups were broken down into the various combinations of treatments, comparisons often were based upon only three or four students in each group. Such comparisons were deemed unmeaningful, therefore, the three year data set, and its proposed analyses, were abandoned.

Way (1984) examined CAI's effect on achievment measures and perceptions collected from students, teachers, and CAI lab aides. Analysis of covariance (ANCOVA) derived from achievment data at the junior high school level showed that the eighth grade students attending CAI labs had significantly higher scores than the comparison eighth grade students on all of the Iowa Tests of Basic Skills (ITBS) achievment measures examined. ITBS achievment levels included the Mathematics Computation Test, The Mathematics Concepts Test, the Mathematics Problem Solving Test, and the Mathematics Composite Score.

The perception data revealed that students liked to work on the CAI lessons and thought the lessons improved their skills in mathematics. Students thought the computer took too long to respond when they had given it an answer.

Gourgy, et al. (1984) utilized the CCC CAI curriculum to enhance student achievment in the basic skill areas of of reading, language arts, and mathematics. The regular CAI program in mathematics, like the program in reading, appeared to be more beneficial for students qualifying for remedial services than for students of average achievment. Comparison of three different instructional management strategies used to administer the CAI to remedial students (formal; coordinated instruction; extended solitary practice; and affective encouragement) showed that for mathematics achievment, coordinated instruction was the most effective strategy, followed by affective encouragement and, lastly, solitary practice.

Chamberlain (1986) instituted a cost-benefit analysis to determine the effectiveness of CAI as an alternative to conventional methods of compensatory reading instruction. The cost per pupil was found to be greater in the CAI groups than in the regular groups at the elementary, middle, and high school levels.

Comparison of NCE gains varied according to school level. At the elementary level, NCE gains were nearly the same for regular and CAI groups, with a difference of only one tenth of an NCE. At the middle school level, the CAI group surpassed the regular group by 1.4 NCE's. There was negative change in both groups at the high school level.

In a two semester case study Payne (1986) evaluated a CAI project in an all minority high school. Modest achievment, higher internal locus of control, and more positive attitudes toward school were observed of CAI students contrasted with non-CAI students. These effects were particularly pronounced for students in Language Skills, Chemistry, Algebra, and Mathematics.

Guerrero and Swan (1988) initiated a CCC Computer Pilot Program designed to identify systems that are effective in increasing at-risk student attendance and achievment, and in improving student and staff attitudes toward CAI. As an evaluation method, interviews were conducted with program administrators and coordinators, teachers and paraprofessionals implementing the program, and with a sample of students.

Overall, generally positive reports came from staff and students at all sites involved. The authors reported that consistent use of any well-structured computer programs dedicated to mathematics and/or reading remediation benefits students in need of such help.

Studies Reporting Negative Results

The first study finding negative results is a Ragsdale (1982) study which claimed that poorly developed materials, locally developed materials, and widespread copying of materials negate any positive impact technology may have in a school district. Premature and inadequate implementation of materials renders research ineffective, and therefore has a negative influence on computer uses in education.

And Carol Ascher (1984) suggested that microcomputers may be widening the gap between rich and poor schools and talented and underachieving students. Rich suburban students were exposed to programming, and the development of Higher Order Thinking Skills (HOTS), while disadvantaged students were more likely to be exposed to CAI drill and practice. Public schools in poor districts and small parochial schools were the least likely to own computers. Ascher asked these questions of schools serving disadvantaged populations:

"Are these groups of students being served equitably in their exposure to computers? And when they are learning to use computers or receiving CAI, is the curriculum best suited to their needs?"

The most recent research that reports negative results is a study by Ngaiyaye and Vanderploge (1986) who investigated the effects of CAI on mathematical concepts, problem-solving, and computation. The purpose of the study was to determine whether CAI affects the achievment levels of educationally disadvantaged students. The ANOVA tables indicated that in no instance did the treatment factor, grade, and pretest effects, reach significance. On the basis of the data analyzed, the evidence was insufficient to support the contention of superiority of CAI.

Summary

Among the major findings of the research, attitude evaluation was found to occur most frequently concurrent with achievment. Cost effectiveness was also included in four of the studies, and CAI was found to be cost effective when compared to traditional instruction. Table 1 quantifies these effects:

Table 1

The Effectiveness of CAI Related to the Review of Literature

Category	Effective	Not Effective
Achievment	14	3
Attitude	5	0
Cost	3	1

The preponderance of evidence supports the idea that CAI helped students learn, and that student and staff attitudes towards CAI was positive. The initial cost of implementing CAI is more than regular instruction, but when coupled with enhanced achievment and attitude, becomes an attractive means of learning. Also, the long term cost is offset by the amount of time the equipment remains current, and product support provided by the participating hardware and software supplier.

The negative conclusion drawn with respect to the Ngaiyaye and Vanderploge (1986) study had inherent sample problems. CAI students had higher pretest scores than the control group. This led the authors to believe that students were not assigned to the program randomly, therefore raising doubt that covariance analysis could effectively adjust for preexisting differences. The authors admitted in their conclusion that every teacher and principal they talked to fervently supported not only CAI, but a particular brand of CAI. Also, that the study may have failed to uncover significant differences simply because of the design used and the sample available for investigation.

In the case of the Ragsdale (1982) study, the claims of poorly developed materials, widespread copying, etc., simply do not hold true any longer. Software design is becoming increasingly complex, and in the case of the CCC curriculum, able to address not only drill-and-practice, but Higher Order Thinking Skills (J. A. Williams, personal communication, February 28,1991).

And similarly, Carol Ascher's claim that little research has been conducted with regard to poor, underachieving, disadvantaged students, no longer holds true. Suppes (1972), Edwards (1975), Fisher (1975), Burns and Bozeman (1981), Ragosta (1982), Hotard and Cortez (1983), Kulik (1983), Gourgy (1984), Niemec and Walberg (1985), and Guerro and Swan (1988) report advantages for underachieving disadvantaged students. Also, the gap that she talks about between rich and poor districts does not take into consideration the research evidence that supports Chapter I funded CAI.

Donna Lee Dowdney (1987) summarizes why educators support the use of CAI:

> "[CAI] provides individualized instruction appropriate for any learner population, regardless of age, socio-economic background, or skill level. . . . Gives students immediate feedback whenever they answer questions; moreover, the program then directs students to new concepts if they answer correctly or to additional practice if they answer incorrectly. . . . Speeds up learning. On the average, students gain one and one-half years for each year they use CAI. Therefore, disadvantaged students have a chance to catch up with their peers. . . . Provides almost unlimited supplementary practice to support classroom instruction. . . . Increases

the successful students' motivation and self-esteem. This leads to less truancy and fewer behavior problems and more high school graduates."

Conclusion

The above review allows for the following generalizations that are pertinent to this study:

1. CAI used as a supplement to traditional instruction produces an educationally significant improvement in students' final examination achievment.

2. Students exposed to CAI may develop more positive attitudes towards computers, instruction, and the subject taught.

3. CAI is more effective with low ability or disadvantaged students than with average or above average students.

4. Although CAI has been shown to be effective at all levels, it appears to be relatively less effective as one goes from elementary to secondary to college levels.

5. CAI is cost effective.

This study builds on the research base in five ways. First, it provides data related to the current state of technology. Second, a comparison analysis of Raw Score, and NCE gains between CAI treatment and regular instruction groups is included. This is similar to the Chamberlain study which sought to determine the effectiveness of CAI as an alternative to conventional methods of compensatory reading instruction. Third, ANCOVA is applied as an analysis measure on four ITBS mathematics subtests (Math Concepts, Problem Solving, Computation, and Math Total) of students to statistically adjust post-test scores. This procedure makes the CAI treatment and regular groups as statistically similar as possible for a final achievment gain comparison. In this way, this study is most similar to the Way study. Fourth, surveys were administered to all students and teachers involved in CAI and regular instruction to determine their attitudes towards CAI. Again, this is similar to the perception data gathered by Way in which questionaires were administered to selected students and teachers involved in CAI. Fifth, this study includes a cost analysis similar to the Chamberlain Cost-Benefit Analysis for 1985-86. In this and Chamberlains' study, analysis is based on per-pupil cost for the computer laboratory, teachers, and aides versus cost per-pupil for regular instruction.

In summary, this study is an extension of, and has similarity to, Ways' Evaluation Of Computer Assisted Instruction 1983-84, which contained ANCOVA analysis of ITBS mathematics scores and perception data collected through questionaires, and Chamberlains' Cost-Benefit Analysis for 1985-86, which compares cost per pupil of CAI and regular instruction, and NCE gains between these two groups. In this way, this study is a current, and comprehensive analysis of achievment and cost of CAI.

CHAPTER III

METHOD

This study investigates the effectiveness of the Computer Curriculum Corporation (CCC) CAI system at Robert Fulton Middle School in Milwaukee, WI for the 1989-1990 school year. Analysis of the problem produces research questions. The research questions relevant to this study are:

Is supplementary CAI more effective than regular classroom instruction in raising math achievment?

Does CAI have a positive effect on students' and teachers' attitudes?

Does CAI cost more than regular instruction, and if so, can the cost be justified?

At Robert Fulton Middle School during the 1989-90 school year, a new three year phase of Chapter I funded CAI was implemented. By October 1, 1989, eighth grade students who were assigned to Fulton were placed in five heterogeneous groups, four of which received CAI as a supplement to regular instruction, and one that received regular instruction alone.

Overview

First, a description of the subjects that participated in this study is given, with a discussion why these subjects were chosen. Following is a discussion of the research design. Next, a description of the instruments used to gather data is discussed relative to the study questions. Last is an explanation of how the data was analyzed with reasons given for the analysis choices.

Subjects

At the time of this study, Fulton Middle School was racially isolated with a student population 96 percent African-American. Located in a neighborhood characterized by poverty, Fulton was one of only two segregated middle schools in the district. Student achievment was low with only eight percent of the students scoring at or above the national average in reading and mathematics. The student grade point average was 1.68 on a 4.00 scale. Average student attendance was 85 percent compared to an average of 91 percent at all Milwaukee Public Schools (Appendix A).

The subjects chosen for this study were eighth grade students at Fulton Middle School during the 1989-90 school year, and received instruction in mathematics and/or CAI for at least eight months. They were placed in five heterogeneous groups by the principal at the beginning of the school year. Also, they were chosen on the basis of whether they could be accounted for with regard to the Iowa Test of Basic Skills (ITBS) pre-, and post-test. Of 148 students tested on ITBS in April, 1990, 59 could be accounted for -- 44 with Computer Curriculum Corporation (CCC) CAI instruction, and 15 non-CAI.

The reasons this group of students was chosen for study were threefold. First, because these students were typically disadvantaged underachievers, there was a demonstrated, urgent, need to identify a system of learning that was effective with these students. Second, the eighth grade students represented in this study presented a unique opportunity in which to implement a comparative study of CAI treatment and non-treatment groups. Enrollment exceeded the programmable limit of the CAI lab. Thus, there existed a non-treatment control group on which to base a comparison. This was not the case in subsequent years of the Chapter I program, where under normal enrollment circumstances all students received CAI treatment. Therefore, this study is limited to the 1989-90 school year. Third, the author was the eighth grade math teacher of these students during the 1989-90 school year. This afforded the opportunity to observe the students and related eighth grade faculty on a consistent basis.

Research Design

The focus of this experiment was one unit of eighth grade students. A unit consisted of approximately 150 students divided into five classes of thirty students each. Four of these classes were broken down into rotation groups which received CAI instruction in addition to regular class instruction, and one class remained intact and received regular instruction only.

A rotation group consisted of sixty students (two classes), divided into three groups of twenty. Each group of twenty moved to three different classrooms during a two-period time block of one hour and forty minutes. One of the classrooms was equipped with twenty CCC terminals where two Chapter 1 para-professionals monitored each student's progress on the system. Students received fifteen minutes of instruction in math, and fifteen minutes of reading daily on the CCC system from September to June.

In an adjacent classroom a board-funded reading teacher, with twenty students, introduced new reading skills, extended reading skills mastered, and provided intervention in reading skill strand areas that the student had failed to master as indicated by the weekly course and group reports generated from the CAI lab.

In the third adjacent classroom a board-funded mathematics teacher, with twenty students, introduced new math skills, extended math skills mastered, and provided intervention in mathematics skill strand areas that the student had failed to master as indicated by the weekly course and group reports generated by the CAI lab. During the two-period block of time, (100 minutes), each group of twenty students remained in each of three classrooms for thirty-three minutes.

In summary, one rotation grouping consisted of sixty students and utilized three adjacent classrooms -- one of which was a CAI Laboratory and included two Chapter 1 funded paraprofessionals, one for a board-funded math teacher, and one for a board-funded reading teacher. Appendix B illustrates this concept.

The study included one unit of eighth grade students -- two rotations of sixty students (experimental group), and one class of thirty students not receiving the rotation (control group). The control group received one fifty minute course daily of both mathematics and reading totaling 100 minutes. These classes were taught by the same board funded teachers that taught the experimental group, and utilized the same curriculum. In essence, four classes received the CAI/Math/Reading rotation, and one class received the traditional fifty minute math and reading course.

Although all students in the experiment were in one common unit, the control group was isolated from the experimental group for all classes. The control group ate lunch at a separate table, and took Fine Arts and Vocational Education (FAVE) courses at a different time than the experimental group. Contact between the experimental group and the control group was kept at a minimum to minimize any unwanted intergroup effects.

Instruments

Four types of data were utilized to determine the effectiveness of the CAI program. First was the Math Achievment Test (Appendix C). This was an instrument designed by the Milwaukee Public Schools and used to determine grade level equivalency of students. The primary purpose of administering this test was to find initial grade levels in which to place students on the CAI system. It was used as a pre-test this way, but administered to CAI as well as the non-CAI groups. It was also administered as a post-test to both groups at the end of the school year to test for achievment. The function of the test relative to this study was to serve as an initial set of pilot data. The raw scores of these tests were analyzed to determine if there were significant gains of the CAI groups over the non-CAI group. If this proved to be the case, then further investigation of ITBS was deemed justifiable.

Second, the Iowa Test of Basic Skills (ITBS) pre and post-tests were analyzed for the purpose of comparing achievment in Math Concepts, Problem Solving, Computation, and Total Scores. This set of data provided extended insight in determining the effectiveness of CAI relative to the particular math strands.

Third, questionaires were administered (Appendix D) at the end of the school year to the CAI group and non-CAI group to determine their attitudes about learning with computers. The student questionaire was given in the students' regular math class by the regular math teacher, and included questions such as "Do you like the way I teach math?", and "Do you understand my directions?". In this way the questionaire served as a student evaluation of the math class, but also included the key question, "Do you like studying on computers?". This question served as an indicator of students' attitude towards CAI, or computers in general.

Also, surveys were given to teachers involved with CAI at Fulton, designed to gather opinions about the CCC program (Appendix E). Questions utilized in this study included, "Is there increased student motivation and interest in your classroom program as a result of your students' participation in the computer curriculum?", "Have you seen evidence this year that the use of computers has led to higher student achievment?", and "For those students functioning below grade level have you noticed any significant improvements?"

Fourth, a cost outlay for the CAI lab (Appendix F) was calculated on a per-pupil basis for CAI students and compared to the per-pupil cost for regular instruction for students. This was done to satisfy the question of CAI cost effectiveness.

Analyses

The Math Achievment Tests were analyzed utilizing raw score gains. This produced a clear mean gain with which to compare the CAI treatment groups to the non-treatment group. When these scores were established and compared, the next step was to analyze ITBS.

Each strand of the ITBS mathematics test, for each student, was analyzed for raw score gains. This gave a clearer representation of each students' achievment with regard to the four strands of ITBS math . The mean gains for each of the four strands were computed for each group and compared. The results illustrated the effectiveness of CAI achievment.

The same procedure was followed utilizing ITBS Normal Curve Equivalency (NCE) gains. Again, the mean gains for each group were compared to identify achievment gains. In addition, the NCE gains represent standings based on nation-wide standard norms.

Finally, ITBS data were analyzed with Analysis of Covariance (ANCOVA). ANCOVA shows mean scores of the experimental and control groups at the end of the school year, adjusted for their mean scores at the beginning of the school year. The adjusted mean scores are approximations of the mean scores that the groups would have earned had they started with equal achievment at the beginning of the school year. ANCOVA represented the most accurate form of analysis with regard to a pre-test, post-test, treatment, non-treatment, group study. When ANCOVA was completed, and the treatment, non-treatment groups compared for achievment, the next step of analysis was initiated.

Questionaires given to students were tabulated for responses regarding the question "Do you like studying on computers?", and put into box-score form. Data from the teacher survey was tabulated regarding the questions "Is there increased student motivation and interest in your classroom program as a result of your students' participation in the computer curriculum?", "Have you seen evidence this year that the use of computers has led to higher student achievment?", and "For those students functioning below grade level have you noticed any significant improvements?", and also put in the box-score format. The box-score format is clear, and represents a quantitative analysis of students and teachers attitudes towards CAI. Data from the teacher survey also indicates teachers' observations of their students achievment as a result of student involvement with CAI.

Last, a cost comparison between CAI, and non-CAI students was computed. The initial cost of CAI was added on to the cost of regular instruction because CAI students also received regular instruction. However, CAI costs were averaged over three years to offset the initial cost of the computer hardware, and to allow for the length of the Chapter I program. The final cost analysis allowed for a per-pupil, achievment versus cost comparison.

In summary, this study focused on the mathematics achievment of approximately 150 urban African-American eighth grade students relative to Computer Assisted Instruction. Pre-, and post-test data was collected and analyzed with respect to an experimental/control group design. Also, questionaires were given to study group students to determine their attitude towards CAI, and surveys were given to teachers of the study group students to determine teachers' perceptions of student achievment. Finally, a cost outlay for the CAI lab was calculated on a per-pupil basis for CAI students and compared to the per-pupil cost for regular instruction for students.

CHAPTER IV

RESULTS

This chapter presents the results obtained from the application of procedures described in Chapter III. First, a brief description of subject attrition for each study group is presented with an acompanying table showing the final sample size of each study group. Second, the mean raw score data for each study group related to the Math Achievment Test is shown. Third, the mean raw score data related to Iowa Test of Basic Skills (ITBS) on Math Concepts, Problem Solving, Computation, and Math Total Scores for each study group is presented. Fourth shown is the Normal Curve Equivalency (NCE) data for the same mathematics strands and study groups. Fifth, a comparative significance of Analysis of Covariance (ANCOVA) between the CAI treatment groups and non-CAI treatment group applied to ITBS raw scores and NCE data on Math Concepts, Problem Solving, Computation, and Math Total Scores is presented. Sixth and seventh, responses of student subjects to the Student Questionaire, and teachers involved with CAI to the Teacher Survey are tabulated. Eighth, a cost per-pupil for regular instruction versus supplementary CAI is calculated and shown for a three year period starting with the 1989-90 school year.

Final Sample Size

The subjects chosen for this study were eighth grade students at Fulton Middle School during the 1989-90 school year, and received instruction in math and/or CAI at least eight months. Also, they were chosen on the basis of whether they could be accounted for with regard to ITBS pre, and post test. Of 148 students tested on ITBS in April, 1990, 59 could be accounted for - 44 with Computer Curriculum Corporation (CCC) CAI instruction, and 15 non-CAI. The final sample size of each study group is shown in Table 2. 8-1, 8-2, 8-3, and 8-4 represent CAI treatment groups, and 8-5 represents the non-CAI treatment group.

Table 2

Final Sample Size of Each Study Group

Group	Size
8-1	11
8-2	12
8-3	11
8-4	10
8-5	15

Test Data

First presented are the mean scores of all study groups on the Math Achievment Test. The pre-test scores were collected at the beginning of the 1989-90 school year and the post-test scores at the end of the 1989-90 school year. The scores represent grade level equivalency.

Table 3

Mean Scores of All Groups on the Math Achievment Test

Group	Pre-Test	Post-Test	Gain
8-1	5.47	7.19	1.72
8-2	5.20	6.32	1.12
8-3	5.37	6.75	1.38
8-4	4.92	6.45	1.53
8-5	5.16	5.23	.07

Once it was determined that the CAI treatment groups demonstrated significant gains over the non-CAI treatment group on the Math Achievment Test, the mean raw scores of all groups on ITBS Math Concepts, Problem Solving, Computation, and Math Total Scores were calculated and tabulated. Tables 4, 5, 6, and 7 show the results:

Table 4

Mean Raw Scores of All Groups on ITBS Math Concepts

Group	Pre-Test	Post-Test	Gain
8-1	19.82	20.10	. 27
8-2	16.50	17.42	.91
8-3	17.73	20.45	2.72
8-4	16.90	18.50	1.60
8-5	17.13	17.00	- .13

Table 5

Mean Raw Scores of All Groups on ITBS Math Problem Solving

Group	Pre-Test	Post-Test	Gain
8-1	11.90	14.20	2.28
8-2	10.00	10.83	.83
8-3	10.36	13.64	3.28
8-4	11.00	12.80	1.80
8-5	8.66	8.86	.20

Table 6

Mean Raw Scores of All Groups on ITBS Math Computation

Group	Pre-Test	Post-Test	Gain
8-1	22.09	22.00	- .09
8-2	20.75	17.08	-3.67
8-3	20.54	19.90	- .64
8-4	18.20	16.80	-1.40
8-5	19.26	15.66	-3.60

Table 7

Mean Raw Scores of All Groups on ITBS Math Total Scores

Group	Pre-Test	Post-Test	Gain
8-1	53.81	55.73	1.92
8-2	47.41	45.33	-2.08
8-3	48.63	54.00	5.37
8-4	46.10	48.10	2.00
8-5	45.40	41.60	-3.80

Next, NCE data regarding the same mathematics strands are represented:

Table 8

Mean NCE Scores of All Groups on ITBS Math Concepts

Group	Pre-Test	Post-Test	Gain
8-1	37.95	37.60	- .35
8-2	30.30	33.21	2.91
8-3	33.04	39.31	6.27
8-4	31.70	35.50	3.75
8-5	33.52	32.90	- .62

Table 9

Mean NCE Scores of All Groups on ITBS Math Problem Solving

Group	Pre-Test	Post-Test	Gain
8-1	36.17	36.68	.51
8-2	29.59	29.63	.04
8-3	34.48	37.73	3.25
8-4	37.00	36.34	- .66
8-5	28.67	23.97	-4.70

Table 10

Mean NCE Scores of All Groups on Math Computation

Group	Pre-Test	Post- Test	Gain
8-1	42.80	43.62	.82
8-2	40.04	33.06	-6.98
8-3	39.28	38.71	- .57
8-4	32.65	32.82	.17
8-5	35.91	29.56	-6.35

Table 11

Mean NCE Scores of All Groups on ITBS Math Total Scores

Group	Pre-Test	Post-Test	Gain
8-1	37.74	36.50	-1.24
8-2	31.60	30.20	-1.40
8-3	34.21	37.75	3.54
8-4	31.87	34.49	2.52
8-5	29.93	25.32	-4.61

When raw score and NCE data were established and compared, the next step was to test for significance of F. Tables 12 and13 show the comparative significance of ANCOVA between the treatment groups (8-1 through 8-4) and the non-treatment group (8-5) on raw and NCE scores for all mathematics strands of ITBS.

Table 12

Significance of F Between the Treatment Groups and Non-Treatment Group on the Raw Scores of ITBS Math (All Strands)

	Sig. of F			
Group	Math Concepts	Problem Solving	Computation	Total
8-1/8-5	.759	.787	.129	.188
8-2/8-5	.564	.761	.952	.581
8-3/8-5	.340	.299	.020	.164
8-4/8-5	.299	.258	.280	.168

Table 13

Significance of F Between the Treatment Groups and Non-Treatment Group on NCE Scores of ITBS Math (All Strands)

	Sig. of F			
Group	Math Concepts	Problem Solving	Computation	Total
8-1/8-5	.526	.320	.216	.921
8-2/8-5	.269	.400	.190	.500
8-3/8-5	.312	.925	.200	.972
8-4/8-5	.756	.487	.876	.741

Student Questionaire

At the end of the 1989-90 school year, students in all study groups were given an evaluation questionaire. Included in the questionaire was the question related to their attitude towards learning on computers, "Do you like studying on computers?". Table 14 quantifies students' responses.

Table 14

Responses of Students to the Question "Do you like studying on computers?"

	Response			
Group	Yes	No	Sometimes	No Opinion
8-1	10	0	1	0
8-2	9	1	2	0
8-3	6	1	3	1
8-4	7	0	3	0
8-5	12	2	1	0

Teacher Survey

Eight teachers whose students were involved with CAI during the 1989-90 school year were given surveys to determine their perceptions of student success as a result of CAI instruction. Of eight surveys distributed, seven were returned. Table 15 quantifies this data.

Table 15

Teacher Responses to Questions Regarding Student Success in CAI

Question	Scale					
	Yes				No	No Response
	1	2	3	4	5	
Is there increased student motivation and interest in your classroom program as a result of your students' participation in the computer curriculum?	2	2	0	0	2	2
Have you seen evidence this year that the use of computers has led to higher student achievevment?	1	3	1	2	0	1
For those students functioning below grade level have you noticed any significant improvements?	2	3	0	2	0	1

Cost Analysis

The final step in the analysis of this study was to perform a per-pupil cost analysis of CAI versus non-CAI students. CAI cost was calculated for all students who received CAI instruction during the 1989-90 school year. For the 1989-90 school year the cost of CAI was calculated by dividing the total cost of three CAI labs represented in APPENDIX F by three. The resulting cost was $116,046.66. This cost was divided by 148 -- the number of students who received CAI instruction in this lab. The resulting cost was $784.00 per pupil. This amount was added to the cost for regular instruction (Basic Facts 1990-91 by DPI).

At the time of this writing, the author was able to calculate costs for the 1990-91 school year. In this year of operation, the only added cost for CAI was for salaries, purchased services, and supplies. Assuming a 5% increase in CAI costs and the same number of students receiving CAI instruction, per-pupil cost was calculated at $268.00. This amount was added to the cost of regular instruction for the 1990-91 school year. The cost of regular instruction for 1990-91 was up 12.3% over 1989-90 (Basic Facts 1991 by DPI).

In order to project costs into the 1991-92 school year, the author assumed another 12.3% increase in cost for regular instruction, a 5% increase in cost for CAI, and the same number of students receiving CAI instruction. Table 16 compares per-pupil cost for regular instruction versus supplemental CAI.

Table 16

Per-Pupil Cost For Regular Instruction Versus Supplemental CAI, and % Increase

Year	Regular Instruction	Supplemental CAI	%Increase
89/90	6032	6860	13.0%
90/91	6774	7042	4.0%
91/92	7607	7888	3.7%

CHAPTER V

DISCUSSION

The purpose of this study was to investigate the effectiveness of the Computer Curriculum Corporation (CCC) CAI system at Robert Fulton Middle School in Milwaukee, WI for the 1989-1990 school year. Analysis of the problem produced research questions. The research questions relevant to this study were:

Is supplementary CAI more effective than regular classroom instruction in raising math achievment?

What are students' and teachers' attitudes towards CAI?

Does CAI cost more than regular instruction, and if so, can the cost be justified?

In order to answer the research questions, five groups of eighth grade students were employed - four receiving supplemental CAI, and one receiving regular instruction alone. The research design employed here can be described as a pre-test/post-test control group design. In regard to this design, data related to grade level equivalency was collected utilizing the Math Acheivment Test, as well as raw score and Normal Curve Equivalency (NCE) scores on four mathematics strands of Iowa Test of Basic Skills (ITBS). When these scores were established Analysis of Covariance (ANCOVA) was applied to test for significance of $\underline{F}$. In addition, questionaire data was collected from study group students and their teachers to determine students' and teachers' attitudes towards CAI. Finally, a cost analysis was calculated based on per-pupil cost for regular instruction versus supplementary CAI.

Test Data

As was expected, pre-test data on the Math Achievment Test regarding the population studied revealed that students' grade level equivalencies were more than two years below their actual grade level placement. Post-test data showed all CAI treatment group gains above those of the non-CAI group with the lowest gain 1.05 years, and the highest 1.65 years. Since all students had the same teacher for math, and received instruction equally except for CAI treatment and the added regular instruction time the non-CAI group had as a result of not participating in a CAI rotation, these gains clearly must be considered significant.

Further, CAI treatment groups show gains over the non-CAI group on all strands of ITBS raw and NCE scores except Computation, where all groups show a negative gain, and one CAI treatment group shows more negative gain than the non-CAI group. One explanation for this may be that a disparity existed between the expectations of the teaching system and the assumptions of the way students perform computations on ITBS, e.g., students are beginning to use calculators regularly to perform basic calculations as opposed to paper and pencil computations expected on ITBS. Another related explanation is that students' attitude towards taking the test may be diminished because the use of technology, as students are becoming accustomed to, is not addressed in ITBS Computation.

On other strands of ITBS, the CAI treatment groups show clear gains over the non-CAI group. Mean raw scores on ITBS Math Concepts shows a negative gain for the non-CAI group while all CAI treatment groups show positive gains. The most positive gains of CAI tratment groups over the non-CAI group occured on the ITBS Math Problem Solving strand. The non-CAI group scored .20 gain in raw scores represented as -4.70 gain in NCE's. In comparison, the CAI treatment groups scored a low of 1.80 gain in raw scores (-.66 NCE's) and a high of 3.28 in raw scores (3.25 NCE's). Gains in Problem Solving are considered most significant for two reasons. First, problem solving skills ranks high on the National Council of Teachers of Mathematics (NCTM) and the National Science Foundations' (NSF) agendas. Second, the gains shown by the CAI treatment groups over the non-CAI group indicate that problem solving was addressed by the CAI system. CAI is usually considered to consist mostly of drill and practice in basic facts with problem solving receiving little attention. Although these CAI treatment groups may have received drill and practice in basic skills (which students who are more than two years behind in grade level demonstrate a need for), it is clear that they also became better mathematics problem solvers.

Ancova

The pre-test raw and NCE scores of ITBS vary somewhat between each study group indicating a failure to control adequately for incoming differences and random assignment of study subjects to groups. This study occurred in a natural setting without complete control over the study subjects, so some differences were expected. Also, the pre-test scores of CAI treatment groups were not always higher than those of the non-treatment group. This suggests that there was a somewhat heterogeneous mix of students assigned to each study group. For these reasons, it was assumed that covariation could be used to adjust for any differences. Tables 12 and 13 indicate, however, that in only one instance did the F-ratios reach significance ($p<0.05$). The main reason for these results is that the final sample size of each study group was too small to test for significance (Dr. Naveen Bansal, personal communication, July 19, 1991). On the basis of the data analyzed for this study, and from a statistical significance standpoint, there is insufficient evidence to suggest that supplemental CAI produces higher acheivment scores than regular instruction.

Student Questionaire

The results of the Student Questionaire revealed that most students liked studying on the computer, indicating that students have a positive attitude towards studying on computers. Based on the personal observation of the author, and in regard to raw and NCE data and the fact that the CAI treatment groups did study comprehensively on computers during this study, achievment gains may indicate a direct relationship between students' attitude and the way they learn.

Teacher Survey

Similarly, teachers' responses on the Teacher Survey indicate that most teachers perceived increased motivation and interest, higher achievment, and significant improvement for students who were involved in CAI during this study. Also, teachers' positive responses about their students' involvement with CAI may indicate that teachers have a positive attitude towards CAI.

Cost Analysis

Although cost for CAI is higher than regular instruction alone, cost for CAI decreases each year over the three year term represented by Table 16. One reason for this is the fact that once the computer hardware was in place, the only added cost was for salaries, purchased services, and supplies. Computer Curriculum Corporation provided software updates and product support related to any hardware failure. The cost of regular instruction alone rose faster than the cost of CAI operation.

Another factor to take into consideration is that CAI at Robert Fulton Middle School was Chapter I funded over the three year term represented in Table 16. The costs presented were well within the Chapter I allowances for this school, and as such are considered to be cost effective means of instruction.

Conclusion

On the basis of raw and NCE scores on all mathematics tests except Computation it can be concluded that CAI produces achievment gains in the subjects studied, e.g., urban African-American middle school students, academically two years or more behind their peers based on nation-wide standardized norms, and especially in problem solving skills. The fact that negative gains are shown in Computation can be explained in a combination of two ways. First, the subjects were unable to perform the calculations required in the Computation portion of ITBS. This may be partially true; however, if this were the case, it is unlikely that the same students would excel at problem solving. Second, and more likely, the subjects were unwilling to perform the calculations required in the Computation portion of

ITBS. Mathematics education was in a transitional period at the time of this study. Students were being exposed more to technological means of performing algorithms associated with various computations, e.g., calculators and computers, and less with paper and pencil computations. At the same time, students were being expected to perform lengthy paper and pencil algorithms to arrive at answers on ITBS Computation. Because ITBS had not addressed more technological means of performing computations, it may be the case that students' attitude towards taking that portion of the test was diminished.

Achievment gains represented by raw and NCE sores in combination with positive reports from students on the Student Questionaire, and positive reports from teachers on the Teacher Survey indicate that most study subjects had a positive attitude towards learning on computers, and that a positive attitude may have had an effect on achievment gains. The fact that most non-CAI treatment subjects gave positive reports about learning with computers indicated that they had experienced CAI somewhere, or would have liked to experience CAI. This in combination with the fact that the non-CAI treatment group lagged in achievment gains reinforces the idea that CAI treatment does help improve achievment.

With regard to cost effectiveness, two factors come into consideration. First, the cost of CAI in this study was covered under Chapter I funding. Since spending was well within Chapter I guidelines, CAI was considered to be cost effective. Second, it was shown that the per-pupil cost for regular instruction rose faster than the cost for maintaining a CAI lab once it was in place. Even though the cost for supplemental CAI was higher than for regular instruction alone, enhanced achievment and attitude helped to justify the added cost for CAI.

Although the tests of statistical significance rendered achievment gains inconclusive, daily observation of the study subjects by the author instilled the thought that had the final sample size of each study group been larger, the F tests would have supported the trend of improved achievment in the CAI treatment groups.

Limitations

This study was limited to eighth grade CAI lessons in mathematics at Robert Fulton Middle School in Milwaukee, WI for the 1989-90 school year. As was stated in the previous paragraph, the final sample sizes of each study group were too small to account for statistical significance. The transient nature of the urban African-American school-age population, administrative transfer, and other factors resulted in over a 60% attrition rate for each study group. Also, the CAI program at this school was Chapter I funded. As a result there were a limited number of non-CAI study subjects available which led to an overbalance of CAI treatment to non-CAI groups. Replicability would not be desirable under these conditions.

Suggestions For Further Research

Replicability would be desirable under conditions where larger sample sizes are available for this population, and study subjects could be assigned to groups in random order. If sample sizes were large enough, the study could be expanded to include the reading portion of CAI instruction as well as mathematics, and also be longitudinal in nature.

Other suggestions for further reasearch are:

1. Study ways in which to decrease student attrition rate in the African-American population. Unless this factor can be controlled, study of techniques to improve student achievment are severely limited.

2. Investigate the use of technology by students, e.g., calculators, on standardized tests and other forms of assessment.

3. Develop further study on how attitude affects achievment relative to the use of technolgy.

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APPENDIX A
ATTENDANCE DATA

	Absent	Excused	Truant	ship	Attend.	Last Yr.	Enrollment	Attend.	Calc	Calc	Dif.	Staff	Team
TOTALS	55477	33407	22070	580382	90.4	91.6	14489	13104	9.6	90.4	0.0	1008	52
Audubon	3956	1874	2082	40342	90.2	91.4	1002	904	9.8	90.2	0.0	66.0	3.0
Bell	3711	2966	745	37450	90.1	91.1	938	845	9.9	90.1	0.0	63.0	3.0
Burroughs	3106	1771	1335	36780	91.6	92.4	918	841	8.4	91.6	0.0	59.0	3.0
Edison	2817	1308	1509	32622	91.4	91.8	836	764	8.6	91.4	0.0	64.0	3.0
Eighth St.	774	742	32	13718	94.4	93.5	342	323	5.6	94.4	0.0	27.0	2.0
Fritsche	4148	2773	1375	38758	89.3	90.3	965	862	10.7	89.3	0.0	67.5	3.0
Fulton	4387	1111	3276	26674	83.6	88.0	666	557	16.4	83.6	0.0	53.0	3.0
Kosciuszko	3877	1724	2153	30736	87.4	89.0	753	658	12.6	87.4	0.0	62.0	3.0
Morse	2150	1939	211	40834	94.7	95.1	1021	967	5.3	94.7	0.0	65.0	3.0
Muir	4109	3245	864	37964	89.2	91.9	942	840	10.8	89.2	0.0	64.5	3.0
Parkman	2915	1611	1304	24012	87.9	87.1	596	524	12.1	87.9	0.0	45.0	3.0
Robinson	1176	675	501	19608	94.0	94.0	486	457	6.0	94.0	0.0	38.0	2.0
Roosevelt	1649	844	805	25128	93.4	94.4	625	584	6.6	93.4	0.0	42.0	2.0
Sholes	4163	3401	762	34690	88.0	89.3	866	762	12.0	88.0	0.0	58.0	3.0
Steuben	2372	1311	1061	36338	93.5	93.7	908	849	6.5	93.5	0.0	59.0	3.0
Walker	4459	2477	1982	33798	86.8	89.1	855	742	13.2	86.8	0.0	57.0	3.0
Webster	3394	2022	1372	39154	91.3	91.9	972	887	8.7	91.3	0.0	62.0	3.0
Wright	2314	1613	701	31776	92.7	93.8	798	740	7.3	92.7	0.0	56.0	4.0

MONTHLY PUPIL ACCOUNTING REPORT *** OTHER SCHOOLS ***

October 2, 1989 to October 31, 1989

	1/2 Days Absent	1/2 Days Excused	1/2 Days Truant	1/2 Days Member-ship	% of Attend.	% of Attend. Last Yr.	Total Enrollment	Average Attend.	% of Absence Calc	% of Attend Calc	% of Attend Dif.	Auth. Staff	Admin. Team
TOTALS	10087	4765	5322	37672	73.2	72.8	1942	1422	26.8	73.2	0.0	136	11
Craig	768	474	294	2720	71.8	74.3	67	48	28.2	71.8	0.0	11.0	1.0
Demmer	163	143	20	537	69.6	73.8	23	16	30.4	69.6	0.0	2.0	1.0
Hayes	780	170	610	2846	72.6	68.9	82	60	27.4	72.6	0.0	12.0	1.0
Kilmer	1493	674	819	7718	80.7	83.1	199	161	19.3	80.7	0.0	17.5	1.0
Lady Pitts	2716	1478	1238	7014	61.3	49.5	189	116	38.7	61.3	0.0	16.0	1.0
Lapham Park	422	166	256	1517	72.2	72.5	80	58	27.8	72.2	0.0	10.0	1.0
Lincoln Alt. H.S.	1276	410	866	3652	65.1	66.5	88	57	34.9	65.1	0.0	7.5	1.0
Lincoln Voc. Lab.	542	50	492	2021	73.2	76.7	64	47	26.8	73.2	0.0	18.0	1.0
Manitoba Ortho.	309	309	0	3595	91.4	88.6	109	100	8.6	91.4	0.0	0.0	0.0
Pleasant View	514	514	0	2631	80.5	91.2	125	101	19.5	80.5	0.0	23.0	1.0
Sixty-Eighth	1104	377	727	3421	67.7	67.1	184	125	32.3	67.7	0.0	10.0	1.0
Comm. Based							732					9.0	1.0

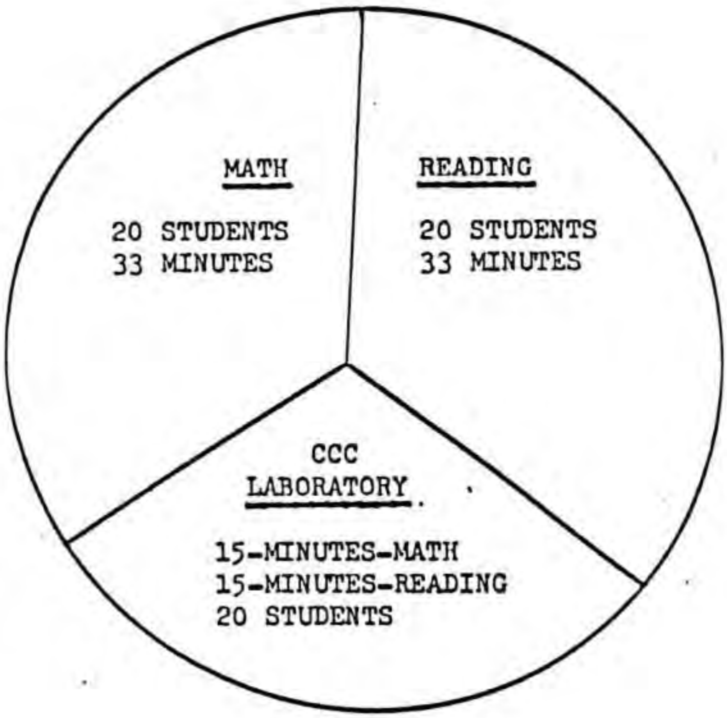
ATT. #1

APPENDIX B

ROTATIONS

READING/MATH/CC ROTATION

60 STUDENTS
100 - MINUTES
in a
ROTATION



BOARD FUNDED

1-READING TEACHER
1-MATH TEACHER

CHAPTER 1 FUNDED

2-PARAPROFESSIONALS

NEED 3 ROTATIONS

ATTACHMENT NO. 3

APPENDIX C
MATH ACHIEVMENT TEST

eacher ______________________ Name ______________________

eriod ______________________ Date ______________________

(20 minutes)

. 2 + 1 = ________ 2. 5 - 1 = ________ 3. 6 + 3

. 8 - 6

5. 32 42 + 40

6. 5 x 2 = ________

'. 32 x 3

8. 39 -18

9. 75 + 6

.0. 452 173 + 254

11. 8 ÷ 2 = ____

12. \$52.08 - 5.30

.3. 2½ hr. = ____ min.

14. 1/5 + 1/5 = ________

.5. 7/966

16. $\frac{16}{4}$ ________

.7. ¼ yd. = ____ in.

18. 8/9 - 4/9 = ________

.9. 2 3/4 = ?/4

20. 832 x 69

.1. 3 1/6 4 2/3 + 2 1/2

22. 2/7 of 35 = ________

	Answers
1.9	1.
2.1	2.
2.2	3.
2.4	4.
2.6	5.
2.8	6.
3.0	7.
3.2	8
3.6	9.
3.9	10.
4.2	11.
4.5	12.
4.7	13.
5.0	14.
5.2	15.
5.3	16.
5.5	17.
5.7	18.
5.9	19.
6.1	20.
6.3	21.
6.5	22.

37/491

24. 3/4 = ?/12

9
-2 1/3

26. ½ yr. = _____ mo.

1 1/3 doz. = ______ items.

28. 7.69
x30.8

Which is more?
8/9 or 13/15

30. Find the average
27, 18, 23, 17, 25

½ = __?__ %

32. 2 1/7 x 2 4/5

7/10 ÷ 1 1/6

34. 7/8 x 8/21 x 3/4

1/3 = _______ decimal

36. 20% of 140 = ?

5^2 = ______

38. 8.3/62.7065

MCCXLII = ?

40. (-6) · (+9) = ____

Find the interest on
$400 at 4½% for 5 mo.

42. y - (8 - 9y) = 32

y = ______

Find the square root $\sqrt{306.25}$

Answers	
6.7	23.
7.0	24.
7.2	25.
7.6	26.
8.2	27.
8.8	28.
9.4	29.
10.0	30.
10.7	31.
11.4	32.
12.1	33.
12.8	34.
13.5	35.
14.2	36.
14.9	37.
15.6	38.
16.3	39.
16.3+	40.
16.3+	41.
16.3+	42.
16.3+	43.

APPENDIX D

STUDENT QUESTIONAIRE

STUDENT QUESTIONAIRE

	YES	NO	SOMETIMES	NO OPINION
1. Do you always know what I want you to do?	___	___	___	___
2. Is math easy for you?	___	___	___	___
3. Do you have many different things to do?	___	___	___	___
4. Do I like you?	___	___	___	___
5. Do you like me?	___	___	___	___
6. Do your classmates like you?	___	___	___	___
7. Do you like your classmates?	___	___	___	___
8. Do you like the way I teach math?	___	___	___	___
9. Do you like studying on computers?	___	___	___	___
10. Do you like the way I discipline your classmates?	___	___	___	___
11. Do you like the tests I give you?	___	___	___	___
12. Do you always know what I want you to do?	___	___	___	___
13. Do you like the assignments I give you?	___	___	___	___
14. Do you like my voice?	___	___	___	___
15. Do I make schoolwork interesting for you?	___	___	___	___
16. Do I help you when you need it?	___	___	___	___
17. Do I give you enough of my time?	___	___	___	___
18. Do you like to help me?	___	___	___	___
19. Do you like to help your classmates?	___	___	___	___
20. Do you like to share your ideas?	___	___	___	___

APPENDIX E

TEACHER SURVEY

COMPUTER CURRICULUM CORPORATION

TEACHER SURVEY

This general survey is designed to gather your opinions about the Computer Curriculum Program. Responses will provide important information to help assess the overall effectiveness of the computer program and assist in the planning for future support and curriculum development.

Thank you for your time and interest in completing this survey.

GENERAL INFORMATION

1. Grade level of your class K 1 2 3 4 5 6

2. Special characteristics of your class (circle)

   Chapter 1 Special Ed. Gifted/Talented ESL Other

3. How frequently during a typical month do you receive computer reports of individual student progress?

   ______ reports per month

4. How frequently during a typical month do you receive computer reports of class progress?

   ______ reports per month

PROGRAM RESPONSIVENESS TO TEACHERS

1. Is the computer curriculum sufficiently comprehensive to provide adequately for the learning needs of your students?

	YES NO		YES NO
Reading	1 2 3 4 5	Mathematics	1 2 3 4 5

2. Is there increased student motivation and interest in your classroom program as a result of your students' participation in the computer curriculum?

	YES NO		YES NO
Reading	1 2 3 4 5	Mathematics	1 2 3 4 5

3. Is there sufficient flexibility in the sequencing of the units so you can align the computer program with your classroom program?

	YES	NO		YES	NO
Reading	1 2 3 4 5		Mathematics	1 2 3 4 5	

4. Have you seen evidence this year that the use of computers has led to higher student achievement?

YES NO
1 2 3 4 5

5. For those students functioning below grade level have you noticed any significant improvements?

YES NO
1 2 3 4 5

6. What problems have arisen in the classroom due to the exposure and/or mastery of an objective presented on the computer before it is introduced in the classroom?

7. Identify ways in which the lab has been supportive of your regular classroom instruction:

8. Identify any intervention strategies you have used effectively in the classroom in conjunction with the CCC lab:

9. What would you change about the CAI lab?
What suggestions do you have for the improvement of the total operation of the CCC lab?

APPENDIX F

CAI COSTS

NAME OF SCHOOL Robert Fulton Middle

CHAPTER 1 SCHOOLWIDE PROJECT BUDGET

SALARIES	Number of Positions	Cost per Position	Amount
Teachers	0	$ –	$ 0
Gen. Aides			
Para Aides	6	13,000.00	78,000.00
Part Time Certificated (for inserv.)			
Substitute Teachers			
Substitute Paraprofessionals – 6		250.00	1,500.00
TOTAL			$ 79,500.00

FRINGE BENEFITS (Total salaries x 32%)	$ 25,440.00

PURCHASED SERVICES		
Consultants	1,500.00	1,500.00
Field Trips	0	0
Inservice	6 Paraprofessionals	500.00
	20 Teachers	4,200.00
TOTAL		$ 6,200.00

SUPPLIES (attached list)	Books – CCC Student Textbooks and Teacher Handbooks	$ 2,000.00
EQUIPMENT (attached list)	60 CCC Learning Systems, 1 Micro Host 3 Printers	$235,000.00

TOTAL PROJECT $348,140.00

AMOUNT ALLOCATED (to be provided by Chapter 1 Office) $348,140.00

* Salaries are to be estimated on the basis of the attached sheet.

1/16/89
Chapter 1 Office

ATTACHMENT NO. 2