Order Number 9020160

A comparative study involving the administration of computer-managed instruction in a remedial mathematics program

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The University of North Carolina at Greensboro, 1989

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A COMPARATIVE STUDY INVOLVING THE ADMINISTRATION OF COMPUTER-MANAGED INSTRUCTION IN A REMEDIAL MATHEMATICS PROGRAM

by

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A Dissertation Submitted to
the Faculty of the Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Education

Greensboro
1989

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November 2, 1989

Date of Acceptance by Committee

September 25, 1989

Date of Final Oral Examination

KESTNER, MICHAEL K., Ed. D. A Comparative Study Involving the Administration of Computer-Managed Instruction in a Remedial Mathematics Program. (1989) Directed by Dr. John Van Hoose and Dr. Kieth Wright. 131 pp.

This comparative study was conducted to gain insight into the effectiveness of two methods of administering a computer-managed component of instruction in a remedial mathematics program. One method of implementing the computer-managed component of instruction involved teacher decisions on what software would be presented to the students. The second administration allowed the computer's management system to diagnose and prescribe software for individual students. A third group not exposed to any computer software was also used in the study.

Five Chapter 1 mathematics classes from each of three middle schools were involved in the collection of data. Pretest and posttest scores were collected on 173 seventh and eighth grade students in order to determine gains in achievement. Informal, structured interviews were conducted with each of the six teachers and five students from each class. Interview data provided information which focused on attitudes toward the use of computers in an instructional setting.

Findings and Conclusions: The analysis of pretest and posttest data support the following: (1) Students whose computer-assisted component of mathematics instruction was assigned by teachers to parallel classroom instruction showed statistically significant higher gains in mathematics achievement than those students whose computer assignments were prescribed by the computer's diagnostic and prescriptive management. (2) Students who received a computer-assisted component in mathematics instruction showed statistically significant gains in mathematics achievement over students receiving no computer interaction. (3) Students and teachers who were involved in use of a computer-assisted component of mathematics instruction reported positive attitudes toward use of computers in teaching and learning mathematics.

ACKNOWLEDGMENTS

I sincerely thank my advisers, Dr. John Van Hoose and Dr. Keith Wright, for their consultation and guidance about my work. I also thank the other committee members, Dr. William Love and Dr. David Strahan, for their energies and genuine team effort on my behalf.

A special thanks to my mother-in-law, Dr. Katherine Conrad, for her kind suggestions and expertise with my writing endeavors. Thanks also to my wife, Tina, for her understanding and encouragement during the whole degree process.

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CHAPTER 1

INTRODUCTION

For over a century American public education has set itself to the overwhelming task of producing a literate and functional society. Additional emphasis has been related to preparing students for the "information age" and the twenty-first century. Students who entered kindergarten in 1987 will graduate from high school in the year 2000 . They will require a different set of skills and knowledge from previous generations if they are to be successful and productive citizens. Former governor James Hunt of North Carolina chaired the Task Force on Education for Economic Growth, sponsored by the Education Commission of the States. The task force has the fundamental belief that education is the key to economic growth. Hunt (1984) suggests that all jobs may not require higher-order skills, yet jobs will increasingly require not just mastery of more advanced technical skills, but also the ability to use those skills and technology creatively in the workplace. "We must educate our young people for the jobs of tomorrow, the jobs that will be available when they leave high school or college. And we must begin now to develop the skills that will be required tomorrow" (Hunt, 1984, p. 538).

One paradox in this era when education is imperative is that millions of American teenagers drop out of school each year. Nationally over one-fourth of American students never complete the requirements for a high school diploma. This statistic not only has consequences for the individual teenager, jeopardizing his/her future, but also for society as a whole (Dowdney, 1980).

Researchers in education and psychology have attempted to uncover variables of effective instruction in order to provide better education for the public. In the last few decades, one of the variables with which researchers have concerned themselves is individual differences involved in cognitive development (Ewing & Roth, 1985). Ewing and Roth advocate that the central focus of individualized instruction should be the delivery of needed instruction for the individual student. However, they did not elaborate on the means of providing such instruction.

Other psychologists have ventured into research of the learning characteristics of the individual student. Three such researchers, Enochs, Handly, & Wollenberg (1985) have found that attributes such as learning style and aptitude have an effect on student achievement. They indicate that the optimal situation would be one teacher and one pupil. Rather than one mode (eg. lecture), teaching is a group of strategies that provides increased interaction both in terms of quality and quantity.

Mathematics is a subject where student differences is highly evident. The nature of mathematics instruction, moving from concrete examples to abstract representations, highlights differences in student learning styles. Discrepancies in mathematics achievement is an area that can best be attended to through individually guided instruction. It is critical to realize that "chalk and talk" is not working for a large number of students trying to learn mathematics.

The middle level student is at a critical period of cognitive development. Adolescents are moving toward an understanding of more abstract concepts. Students who are not developmentally ready will not be able to progress at the same pace as those who are ready. If individual needs are not addressed students will become deficient in skills necessary for further learning.

Mathematics Instruction

The mathematics curriculum has strived to help students acquire necessary skills for functioning in everyday life as well as to think and evaluate situations for themselves. According to recent reports such as "A Nation at Risk" and the "The Nation's Report Card", the schools are missing the mark. In mathematics achievement, "about half the nation's students at this age (17) lacked the mathematical skills usually taught in junior high school, such as computing with decimals, simple geometry tasks, and interpreting graphs" (Roso, 1988, p. 6). Internationally, American ten-year-olds were about at the world-wide average, but fourteen- year-olds placed fourteenth in a field of seventeen. The most recent international mathematics study further emphasizes the status for American students by reporting that average Japanese students exhibit higher achievement than top five percent of American students. (Dosey, Mullins, Linquist, Chambers, 1988)

The educational system in the United States is not used to being relegated to such low status. Countries which out-perform the United States seem to spend more time studying mathematics and begin laying the foundation for higher levels of mathematics at an earlier age. For example, high school students in the Soviet Union are required to take two years of calculus while half of all high school graduates in the United States take no mathematics courses beyond the tenth grade. (Hunt, 1984)

The problem is accentuated by a critical shortage of qualified mathematics teachers. Low pay and declining morale are deterrents to attracting bright young students to a profession in education.

Mathematics instruction appears to be dominated by total group situations and does not involve the individualized approach. Activities are narrowed to lecture, demonstration, some recitation, and seatwork (Henderson, 1986). It is doubtful that knowledge and skills deficits can be remedied in an environment where teachers lecture to large groups or in individualized situations dominated by worksheets and lack of interactions with peers and/or teachers. A student should be exposed to discovery learning and concrete examples of mathematical concepts in addition to paper and pencil exercises with algorithms. Henderson (1986) states that students "without the opportunity to make judgments about their own (individual student's) readiness to take on new problems independently, as seems to be especially true in mathematics instruction, one of the major mechanisms that facilitates transfer of responsibility for the management of learning is missing" (p. 419).

Potential for Computers in Education

The current information age has already made an impact on the direction of the educational system. Appropriately, educators looked at how the rest of the world made use of computers and transformed administrative paperwork into computer functions. Now after twenty-five years of educational use, many questions remain unanswered: (a) Are computers in labs a better utilization than having a couple of computers in individual classrooms? (b) Do low achievers respond to computers better than high achievers? (c) Are computers more effective at elementary levels than at secondary levels? (d) Are computers more appropriate mathematics instruction than in other content areas? (e) Is there an appropriate time limit for computer exposure to ensure maximal achievement gains? (f) Is the computer an exemplary product for use in the American educational system which strives for equal opportunity for all students?

Some of the more relevant questions pertain to the ability of technology to improve achievement in basic skills and the degree to which remedial performance can be improved and dropout rates lowered. Educators are still asking if computers are more effective in any specific content area or grade level or ability level. Questions on effects of attitude toward subject matter, school, and computers themselves are of great interest (Roblyer, 1988).

There is considerable interest in the use of technology in education. With a rise in student population and concern about cost effectiveness, computers are constantly being investigated as an intervention tool. The decline in cost is making computers a topic with realistic possibilities.

Mathematics instruction was one of the first areas to experiment with the use of computers. The sequential order of building skills in mathematics makes computers a viable medium for instruction in that subject. Drill and practice was a simple function easily performed by computers which mathematics educators exploited.

The use of technological information systems would appear a viable alternative to the current status of individualized instruction. These systems can provide a required level of support to move students to higher levels of performance.

It is to be emphasized, however, that technological systems would not be the only instructional strategy. It can be the primary source for instruction or used as support for other structures. No single strategy has been as effective as incorporating a variety of approaches addressing the individual needs of the students.

With continual advancements in technology, the educational system is required to keep pace in what is commonly referred to as the "information age". This requires not only adapting technology to instruction, but also revising curriculum to give students skills and knowledge that will be needed in the future. Educators are challenged to develop a vision for the future and to strive make to make the vision a reality (Papert, 1986).

Escalating school-related computer use mandates a direction to find an effective, efficient approach to integrating technology into the educational process. After instructional objectives have been formulated and content reviewed, the use of technology can be incorporated into activities within the school environment. The student can be exposed to enhanced learner control, interaction with content, and multi-modal presentations.

The challenge for educators is great. A core of supportive research is essential to the success of implementing technology within educational strategies.

Today developers of computer software are offering a management option along with their instructional programs. The management system can not only diagnose deficiencies and prescribe software to address those deficiencies but can also keep records of an individual's progress and produce a variety of reports depicting that progress.

Meeting the Needs of Low Achieving Students

One group which has been targeted for special attempts at individualization is the students characterized as low achievers. The federal government has supported the efforts to meet the low achiever's individual needs via federal funds for Chapter 1 programs. The federal government did not become involved in local education until 1985 with the Elementary and Secondary Education Act. In his attack on poverty, President Lyndon Johnson was able to pass legislation to support compensatory programs. Over the years, the name for these programs has been known as Chapter 1 for the legislation which provides the funds. Many of these Chapter 1 programs have incorporated computer-assisted instruction in their proposals. Gourgey (1987) specifically addressed students enrolled in Chapter 1 programs. These students have a history of not responding to the large group instruction that takes place in traditional classrooms across the country. By the time students reach the middle grades, some already have significant deficiencies in their cognitive development. Some approaches have decreased class size but rely on self-paced paper and pencil seatwork. Such practices are more likely to have students off task and are viewed as detrimental to learning progress and achievement gain (Seifert &Beck, 1984).

Slavin (1987) suggested that the problem with Chapter 1 programs is not the amount of funds, but the programs that the funds create. He felt that it is unlikely that doing more of the same will produce marked differences. The programs which Slavin identified as most effective in accelerating the achievement of students-at-risk of school failure are characterized by elements that include the following: frequent assessment, corrective instruction and regrouping, pacing at individual rates, continuous diagnosis and prescription, and well-defined objectives.

The technological revolution of the information age has promise for addressing numerous needs of today's students. The following list of reasons suggests why computer-assisted instruction (CAI) is so attractive:

[1] CAI provides an individualized instruction at all levels.

[2] CAI allows for individualized pacing.

[3] CAI provides immediate & constant feedback on student input.

[4] CAI creates a positive, non-threatening environment.

[5] CAI can provide personalized tutoring.

[6] CAI can speed up the learning process.

[7] CAI can increase motivation and self-esteem.

[8] CAI can provide student record .

Benefits offered to teachers include less drudgery and repetition, ease of updating materials, less time on documentation of student progress, and better quality time with students (Kulik, Bangert, & Williams, 1983).

There is an increasing interest in the use of computer-assisted instruction in the educational environment. Terms such as computer-assisted instruction (CAI), computer-based instruction (CBI), computer-assisted learning (CAL), and computer-managed instruction (CMI) seem to be generic and include a variety of forms. Some of the most typical styles incorporate drill and practice, tutorial, simulation, and inquiry (Neimiec & Walberg, 1987). Drill and practice computer assisted instruction to supplement regular instruction has enhanced both the cognitive and affective domains (Mevarech & Rich, 1985). Much of the research has involved specific courseware and its effect on student achievement (Gray, 1987).

The research questions suggested by implementing computers as part of the delivery of the curriculum become numerous: most appropriate skill level, most appropriate grade or age, labs versus in-class computers, most appropriate type of software (ie. tutorial, drill and practice, simulation,) Along with the obvious investigation of student achievement, affective elements for the students and teachers also come to mind: Can computer applications improve student attitudes toward school, toward learning and toward their own abilities to learn? Can improved attitudes affect better performance and lower dropout rates?

Purpose and Objectives of the Study

This study attempted to shed light on whether the way specific software is implemented in a curriculum makes a difference in student achievement. The purpose of this study was to examine two methods of administration for a computer-managed component of the mathematics curriculum and their effects on the achievement of students. One method of administration allows for input and decision making by the teacher regarding software in the computer-assisted component of instruction. A second method involves the use of a predetermined software package that was not selected by the teacher. These approaches could then be compared to a class group who received typical mathematics instruction with no use of computer-assisted instruction. Also investigated was the attitudes of teachers and students concerning the use of computer software in teaching and reinforcing mathematics content and skills.

The specific population addressed in the study was seventh and eighth grade students involved in a Chapter 1 remedial mathematics program. The students in the Chapter 1 program fell into categories ranging from "Educationally Disadvantaged" and "High Risk" to those classified for "special education."

Although several criteria were used to rate the efficiency of the two administrative approaches, the most logical choice was to base the assessment on student achievement. The mathematical skills stated in the educational objectives of the North Carolina Basic Educational Program served as the criterion for evaluation. The specific mathematical skills addressed by the study can be found in appendix A.

The objective of the study was to produce evidence as to what degree each method of computer-managed instruction administration affects achievement in mathematics skills and attitudes toward mathematics and school in general. The knowledged gained will benefit educators in their attempt to employ computer-assisted instruction as part of the curriculum.

Statement of the Hypotheses

The method of study was a statistical analysis of student achievement via pretest and post-test scores. Students were administered one hundred question tests designed to determine mastery of basic mathematical skills (see appendix A).

Additionally, students' attitudes toward computers, mathematics, and school were assessed through a structured interview process. Teachers' opinions concerning the role of computers in mathematics instruction and the role of teachers with computer-managed instruction were also collected via structured interviews.

Three narrow questions were addressed in the study. Two of the questions pertain to student achievement in mathematics and the third relates to student and teacher attitudes toward the use of computers as a means of instruction.

The data collection and analysis provided the basis for testing the following hypotheses:

H_1: Students whose computer-assisted component of mathematics instruction is assigned by the teacher to parallel classroom instruction will demonstrate statistically significant higher gains in mathematics achievement than those students whose computer assignments are made by the computer and not aligned with classroom instruction.

H_2 - Students who receive a computer-assisted component in mathematics instruction will demonstrate statistically significant higher gains in mathematics achievement than students not receiving any computer interaction.

H_3 - Students who receive a computer-assisted component in mathematics instruction will report positive attitudes toward use of computers for learning mathematics.

Significance of the Study

The literature is clear that dramatic changes can come about in education as a result of microcomputer use. However, the impact on instruction is not clear. Many early reviews about computers in education have dealt with pre-1980 studies that involved older hardware and software applications. Research is currently focusing in on traditional measures of educational effectiveness: student achievement, attitudes, dropout rate and learning time (Robyler, 1988).

All indications are that the presence and influence of the computer in education will continue to flourish. Despite the continued growth for over a quarter of a century computer-based learning remains a small part of the total instructional system. Moreover, teachers have little training and knowledge in using computers for instruction (Bork,1984).

Proper methods of implementing a curriculum are always important to educators. The use of networked, computer-managed systems of instruction is a relatively new concept (ie. within the last twenty-five years) in the educational arena. No study concerning the method of administration of courseware by a computer-managed system was discovered in an exhaustive search of the literature. Articles supporting the use of such systems were located, but a comparison of different modes of implementation were not evident.

With the increased amount of funds directed toward computer and software purchases, there is a danger of inefficient or improper use of the technology. Many educators prescribe to the belief that a new curriculum must be designed and current teaching practices may not be appropriate with the capabilities technology offers.

Many teachers are not well-trained in the use of technology and are not given release time to learn how to use it in their instruction.

In addition, research has been slow to address the practical question of how technology should be used to enhance student performance and achievement. Educational leaders agree that the potential of educational computing is great. Educators are faced with an abundance of possibilities but there is great need for research to give direction to teachers in the classroom to help fulfill the potential. Komoski (1984) suggests that "the quality of educational computing in a school is going to depend on the quality of the software selected for use in that school and on the way that software is integrated into the overall curriculum" (p. 245).

Field study research in the use of new technologies provides practitioners with vital information concerning application of that technology. This study attempted to address the narrow topic of using a networked computer lab in conjunction with a computer-managed system of courseware with a remedial mathematics program.

Definition of Terms

Computer technology has been accompanied by a new vocabulary. The following definitions will provide clarity for the terminology used in this study.

Computer-Assisted Instruction (CAI) - Interactive instructional techniques in which a computer is used to present instructional material, monitor learning and select additional instructional materials in accordance with an individual learner's needs.

Computer-Managed Instruction (CMI) - use of a computer to maintain and analyze data on learner performance and instructional progress as an aid to teachers in selecting learning activities.

Computer Networks - interconnected computers and peripherals, linked for resource sharing.

Courseware - a collection of computer software modules that gives instruction in specific topics or content.

Educationally Disadvantaged - individuals whose schooling is judged to be qualitatively or quantitatively inferior as compared with what is necessary for achievement in a particular society.

High Risk Students - students with normal intelligence whose academic background or prior performance may cause them to be perceived as candidates for future academic failure or drop out.

Microchip - an electronic processing component for computers that has been shrunk in size enough to allow desktop computers to handle the task of the larger mainframes.

Microcomputer - a computer developed with the onset of the microchip which can accomplish many of the powerful applications of a larger mainframe and still be housed in a case that will sit on a desktop.

Server - a host computer which acts as the main storage for software and other files shared by interconnected computers.

Workstation - an individual computer utilized for interaction with software applications.

Scope and Limitations

This study provided a data analysis for a remedial mathematics program that used a computer-managed component. The student sample was limited to seventh and eighth grade students who were identified as having deficiencies in basic mathematical skills.

The criterion test used for measuring student achievement was concerned with basic skills and concepts. Higher-level thinking and problem solving abilities were not addressed.

The interview information was self-report yet provided insight into the participant's attitude toward computer-managed instruction. An outline of questions is available in appendix B and appendix C.

The study used actual field practices in a school setting and covered a complete semester of instruction. The results can not be considered definitive, but the design may be replicated and further investigation of the topics considered are warranted. Broad inferences cannot be considered until additional research establishes a strong foundation of information.

Summary

Computer-assisted instruction is becoming more evident in school instructional programs. The need to introduce students to new technologies and their capabilities is an important element of the curriculum which cannot be ignored in public education. Educators are becoming increasingly aware that a technologically literate society is essential to ensure continued growth and prosperity. The use of computers as instructional tools provides many advantages, but educators must safeguard against inappropriate and ineffective pedagogical practices.

Educational leaders around the world are encountering similar problems relating to teacher training, lack of hardware and software, and methods for implementation. Professional conferences in all realms of education examine the potentials of technology as a tool to explore information presented in current and future curricula.

The federal government as well as private industry is funding projects that focus on the use of technology in the educational process. Technology is not looked at solely as an enhancement but also as a tool that could drastically change what we teach and how we teach are being experimented with.

A number of factors have contributed to the rising interest in the use of technology in education. Many national and international studies and reports have pointed out the inadequacy of the current educational system to provide quality and productive experiences for students. Public leaders in turn have increased demand for accountability of the schools. The publicity of poor test scores coupled with new research in effective school practices has brought public education to the forefront.

Another factor is the increase in student populations. Managing student information is becoming impossible without the use of tools provided by new technologies.

The lower cost of hardware and better quality software also makes technology an attractive alternative to the current curricular program. The affordability is helping school systems to make computer hardware more available to the classroom teacher.

Computer-managed instruction is one development of technology seen as a possible solution to providing quality education. Comprehensive computer-managed systems allow teachers and administrators to take advantage of technological capabilities to measure students' objective-specific skills.

Testing, scoring, and analyzing results are features common to most computer-managed instructional systems. The benefits of computer-managed instructional systems are realized by teachers, administrators, students and their parents but, the depth and experience seems of current practice is limited.

Teachers' paperwork and the time to evaluate student performance and progress are diminished. Identification of problem areas and curriculum adjustments are simplified.

Students are allowed to work at their own pace on skills which have been diagnosed as deficient. Each student can have weaknesses pinpointed and an individualized educational program developed.

This study attempted to provide information as to whether one administration of such a computer-managed instruction system might be more advantageous than another.

CHAPTER II

A REVIEW OF THE LITERATURE

The use of computers in an educational setting is a relatively new topic to research. Most recorded efforts to utilize a computer as an instructional tool date from the last twenty-five years. The developmental breakthrough of the microchip has streamlined hardware and made computers less expensive and more feasible for classroom use. The production of appropriate software has also caused interest to grow exponentially. Further evidence of the interest in computer-assisted instruction are the journals that have been produced to keep up with the rapid changes in technologies and their applications: *Computing Teacher, Educational Technology, Educational Communication and Technology Journal, Electronic Learning, Family Computing, Journal of Educational Computing, Research, Journal of Computer-Based Instruction, Technological Horizons in Education, et al.*

The review which follows will begin with the exploration of why computers are being introduced into schools and the promise offered by computer-assisted instruction. Related problems and current status of school use of computers are presented. Specifically, mathematics is addressed in subheadings where appropriate as well as in a separate section. The review concludes with several examples of research findings relating the use of computers to student achievement and student attitudes.

Roles for Computers in an Educational Environment

There is growing evidence that the computer can lead to significant innovation in the school curricula and serve as a powerful learning medium. Computers seem to have an undeniable value as an educational instrument and tool. Microcomputers have the capability of introducing new topics or developing and reinforcing skills. Both cognitive development and acquisition of concrete operational skills are possible with microcomputer experiences (Caissy, 1987).

Using computers in a one-on-one environment creates a nonthreatening situation where individual students do not have to fear failure in front of their peers. An individualized program can allow a student to work at his/her own pace with a computer that has endless patience and encourages sustained effort when errors are detected. A computer will also provide the positive reinforcement and confidence building experiences so important in remediation. The student working with a computer is not allowed to be a passive participant in the learning process. Interaction and experimentation are natural attributes for instruction with computers (Kulik, Bangert, & Williams, 1983).

The social effects of computer use have been criticized. Computers used in individualized settings have been studied, but the effects of computers in a cooperative approach are just beginning to be studied. Mevarech (1987) believed that using computers in small groups can be effective in socializing students. He has reported that paired students involved with computer assisted instruction in learning Hebrew were more prosocial and possessed stronger attitudes toward cooperative learning than those who were exposed to individualized computer-assisted instruction. Mevarech also indicated marginally significant differences in achievement ($F(1,113)=2.89$, $p< .09$) that favored the students who had been paired. These implications would be particularly pertinent to the middle-level educators where development of social skills is a major priority. In a different study, Mevarech (1985) also showed that the difference in mathematics achievement between students exposed to individualized computer-assisted instruction (each student working on separate skills) and traditional computer-assisted instruction (students working on the same skill at the same time) was similar to the reported differences between individualized and traditional instruction without computers.

Hartley (1987) indicated that computer-assisted instruction was most effective when used in an individualized instruction program. Some educators fear that the use of computers to deliver instruction will deemphasize the socialization that goes on in schools. However, small group experiences with computer-assisted programs have been found to lead to a cooperative spirit among students. Mevarech, Stein, and Levit (1987) investigated cooperative learning situations in comparison with individualized computer-assisted instruction. Even though achievement is similar, grouped students show higher altruistic tendencies toward their classmates and a higher attitude of cooperativeness.

Hartley (1987) suggested that the enticement of computers for educators has been improved with the technological advances of faster processors, larger memories, and screen/window user functions. With the new enhancements have also come lower price tags to bring them within reach of local school budgets. More and improved educational software is also available and teaching staffs are becoming familiar with computer-assisted learning. Computer applications have grown to include diagnostic and simulation possibilities.

Motivational Aspects of Computer-Assisted Instruction

Alfred Bork (1987) contended that computers allowed educators to transform the learning process into a more attractive, more efficient, and more powerful offering for today's students. He felt that the enjoyment of learning can be reintroduced. Computers motivated better than the current textbook and lecture delivery systems found in public schools. Bork suggested that computer management systems can keep teachers and parents attuned to students' needs and appropriate actions to be taken.

Richard Cyert (1986) is convinced that the emergence of networks of microcomputers will facilitate integration of the technology into educational fields by providing both a stand-alone computer as well as a work station connected to a more powerful computer. Cyert claimed that the ability to decentralize computers will better address the concerns of access and personal preferences for applications. He saw networked computers with appropriate software enhancing comprehension and problem-solving abilities and at the same time improving student motivation to learn. Cyert further suggested that remediation can take place concurrent to other courses, and learning outside the classroom will be stimulated.

Seymour Papert (1986), the creator of the Logo language, believed that computer use is influenced by the educator's vision of the future. He believed that as time passed we would see more genuine rethinking of the function that a computer can satisfy. Papert feels that the microcomputer is helping break the barriers between arts and sciences, between the artistic and the aesthetical, the mathematical and the scientific. As a result, technology is changing the way in which education is perceived. The change will not occur overnight, but take a extended period of time.

Cost Effectiveness of Computer-Assisted Instruction

One concern which inevitably arises when educators begin to examine the use of computers in instruction is that of cost. From the beginnings of computers like ENIAC (electronic numerical integrator and computer), which covered fifteen thousand square feet of floor space in 1946, technology has improved continuously. In only twenty years IBM was able to introduce its model 360, which covers considerably less space and includes 256 K of memory for a price equivalent to $800,000. Even with this kind of achievement the cost is too much for the limited educational market (Alessi, 1985). Currently IBM is making an attempt to claim its share of the educational arena with its personal system 2 series which is equivalent to memory to the old model 360s but sit on top of a desk and has a price tag of less than $2,000.

There have been some studies trying to assess the cost effectiveness of computer-assisted instruction (Levin,1984; Lewis,1987). The attempt was to provide reliable and complete cost information related to gains in achievement. D. R. Lewis (1987) indicated that "contrary to most conventional wisdom about instructional technology, the recently expanded use of microcomputers in education has not contributed a great deal to educational costs." (p. 247) He went further to suggest that the ration of technology costs to labor costs was one to nine, favoring the use of technology. In light of perceived benefits (achievement, learning environment, motivation) and the value of technology to instruction, the money is well spent.

Levin (1984) attempted to compare cost of computer-assisted instruction to other instructional alternatives. His findings indicated that computer-assisted instruction was found to be more cost efficient than reducing class size, increasing the length of the school day, or adult tutoring. The one alternative which is considerably more cost efficient than all of the others was peer tutoring. No mention was made to combining computer-assisted learning in cooperative instructional settings with such tutoring.

Problems Related with Computer-Assisted Instruction

The great promise of technology has increased the number of advocates for increased use of computers in an educational setting. A major educational organization, the National Council of Teachers of Mathematics, has stated a position of including the use of computers throughout the continuum of educational experiences (The National Council of Teachers of Mathematics, 1989).

With such promise offered by technology, what is holding education back ? A variety of answers have been suggested:

1. Lack of quality software is highly criticized. Computer hardware can only be as good as its software. "The greatest obstacle to achieving an educational impact is the need to create new software. If the software can be developed - and some of it already exists - significant changes in education will occur" (Cyert, 1986, p 4).

2. Lack of computer access is a common complaint. However, this concern is slowly being eliminated. A survey in 1985 of computer availability to middle grade educators reported that seventy percent of the teachers had access to computers. The disheartening evidence was that a large percentage with access to computers did not use them.

3. Poor teacher training is one of the top administrative concerns. A factor relating to the slow process of implementing instruction with the aid of computers is the training of classroom teachers. When investigating why teachers who had access still did not use computers, it was found that sixty-eight percent of the teachers had received no training in classroom use of computers (Dickey et al.,1987). However, the conclusion of one research project in Danish schools indicated that teachers, without any special training, are capable of integrating computer assistance to learning in a meaningful way (Lyster, Dalgaard, Belhage, 1981). Although inservice training has begun, many problems exist. Release time is restricted and a range of experience for most teachers is limited.

4. Lack of vision by educators is viewed as a barrier among leaders. Bork (1987) suggested that what is called for is an entire new set of courses with new curriculum materials throughout the entire educational system. Survey data collected by Becker (1987) showed that schools will teach about computers, but not with computers. Resources in education are

still limited and educators do not recognize the full potential of computer-assisted instruction. Teachers do not understand the use of computers in a multi-disciplinary setting and all of the advantages and difficulties which it entails (Hartley, 1987). Educators can only relate to their current needs. As curricula evolve and teachers and students become more comfortable with technology, it may be that the use of computers will grow (Warner, 1987).

5. Large initial cost is a complaint even though shown cost-effective. Cost of computer-assisted instruction is another major consideration and has been discussed in a previous section of this chapter.

A major factor in the enthusiasm for educational computing is the increased affordability and accessibility of the hardware and software. From 1978 to 1984 the cost for a given level of performance has decreased fifty percent or more. Levin (1984) predicts a continued decline in the future costs of hardware. This decline in cost is significant because the bulk of the expense in a computer-assisted delivery program has beem accounted for by the hardware (Levin, 1984).

In 1984 an estimated three hundred million dollars was spent by public schools in the educational computing marketplace. Seven states dominated almost one-third of the total expenditure. The majority of the money was spent on hardware leaving only fifteen percent of the budget for software. Predictions indicate a reversal of this with nearly three-quarters of the computing budgets going toward software by 1988 (Lobello,1984). In any case, the budget figures alone indicate the interest, present and future, that public education has in computer-assisted instruction.

Current Uses

In 1984 mathematics dominated the educational software market. Most of the software was drill and practice oriented. In reviewing educational software in 1987, however, Bitter and Gore (1987), found only twenty-one percent of the titles were mathematics oriented. The continuing emphasis on drill and practice is evidence of the lingering approach to view mathematics as a body of skills rather than concepts and applications. The current emphasis on problem solving and higher order thinking skills is changing the focus of software (Bitter & Gore, 1987).

More simulations and applications for all subjects are being developed. Textbook publishers are seeing computer software as a necessary part of their publications. The role of the computer in the classroom will be determined by how closely the objectives of the software match the objectives of the curriculum (Bitter & Gore, 1987).

Computers are even assuming a diagnostic/prescriptive role. "With the increasing application of artificial intelligence techniques and knowledge engineering to education, such progress will model the teaching behavior of master teachers and will become more sensitive to the individual learning styles" (Bitter & Gore, 1987, p. 34).

Dickey (1987) indicated some reasons why teachers may be reluctant to jump on the computer band wagon. Some teachers report a fear that time needed for instruction in academic topics will be allocated to computer literacy instruction. According to some teachers an appropriate and advantageous use of computers has not been practiced. Teachers using computers report drill and practice, tutorial, and educational game software as the major applications. There is no evidence of using a computer as part of an in-class demonstration. Although previous theory is supported by most teachers, finding a positive effect in both attitude and academic achievement, few teachers sampled find much effect on the learning rate.

Electronic Learning, a periodical which focuses on the use of technology in a school setting, has annually conducted a national survey for the past seven years to examine the level of interest in educational computing. All fifty states as well as the District of Columbia are included in the analysis. Results from the 1986 surveys indicated some states (Colorado, Nebraska, and Pennsylvania) unwilling to risk money on computer programs before seeing proof that computers are helping students learn. However, these states seem to be out of step with the rest of the country. Most states report strong and growing commitments to computer use in the schools. The support from the state level included hardware, software, training, and supervisory personnel. Forty-three states have a state level computer coordinator. Other evidence of state-level support was indicated in the task force on educational technology created by the National Governor's Association (Reinhold, 1986).

The survey results compiled in 1987 showed an increase in most computer related areas. More money was spent for software as well as expenditures for teacher training. Although no state requires all of its teachers to have a course in computers, thirteen states mandate students in teacher degree programs to take a course in computer topics. In 1987, integrating computers into the curriculum had become standard practice (Roberts, 1987).

The trend since 1983 has been to encourage computer use throughout the curriculum rather than specifically in computer competency courses. Now teachers and students are being required to use technology wherever appropriate.

Declining U.S. student test scores in recent years combined with a growing number of technological and information industries, have strengthened public demand for students to learn higher levels of mathematics and to develop thinking skills. Pressure is on the educational system to create new curricula and methods that incorporate new technology and assist students in developing the thought processes and mathematical thinking skills in a highly technological age.

"Parents, teachers, business leaders, and politicians have expressed the need to promote and improve students' higher-order thinking skills" (Rawitsch, 1988, p. 7). The National Governors' Association Task Force on Technology has targeted grants for gifted and talented, computers for teachers, and other innovative uses of technology (Reinhold, 1986).

The use of computer-assisted instruction is seen as a medium of addressing the task. Lappan (1987) believed that

> "Logo encourages rule-making and self-direction that can transfer to non-computer contexts. In addition computer graphics help furnish a link from concrete to abstract ideas. Open-ended software and programming tasks encourage language experiences that increase students' creativity and help them reflect on their own thinking" (p. 33).

Several researchers have also indicated that working with computer data bases developed higher-level problem-solving, increased information management skills, and facilitated critical questioning and hypothesis testing (Hannah, 1987, Hunter, 1983, Parker, 1986).

Challenges have also come from other members of the educational community criticizing publications for making "suggestions for adopting productivity tools to school subject areas with nary an accusation that ... there is no research data to suggest they are of value" (Schiffman, 1987, p. 27).

Use of Computers in Mathematics

Several educational groups have called for changes in the mathematics curriculum. One such group, the Conference Board of Mathematical Sciences, has suggested a new curriculum to provide facility with one-digit facts, place value, decimals, percentages, and exponential notations. Additional emphasis is to be placed on estimation and calculator and computer use. An understanding of data analysis, statistics and probability, and fractions is considered essential in preparing students for the future (Bitter, 1987).

The National Commission on Excellence in Education produce guidelines for a technology-assisted mathematics curriculum. They point out that some traditional topics have become obsolete with capabilities of some of the new technologies. Using tables and interpolation are no longer necessary skills when the power of a simple hand-held calculator can be quicker and more accurate.

The National Council of Teachers of Mathematics (1980) suggested focusing on problem solving; finding solutions to unfamiliar problems that one does not have a set algorithm with which to proceed. High on the list was also development of number sense: the foundation by which students can judge the quantity and understand what numbers represent. The Council also recommended technology-assisted mathematics regardless of specific course content. The focus should be the use and understanding of calculations: what it means in concrete terms to add, subtract, multiply , and divide. Rather than focusing on the procedures and manipulations of numbers, students should concentrate on what their results actually mean or represent. The goal of the curriculum is to develop productive students capable of using new technologies as tools in searching for solutions to real world problems.

Bitter (1987) reinforced the call for reform in the current curriculum. "Any revised mathematics program should introduce the student to practical problems requiring the collection of data, the communication of results and ideas, and the formulation and testing of solutions" (p 23). Bitter also claimed that the use of computer-assisted instruction will not only enhance desired skills but also stimulate interest in fields which require the use of higher mathematics. The technology offers new opportunities for students with limited mathematical skills and at the same time allows more mathematically gifted students to explore whatever heights they wish to achieve.

Teachers need to keep themselves up-to-date about advances in technology and seek training in its uses. Teachers will be called on to make informed decisions on the most appropriate uses for technology (Bitter, 1987). As technology is introduced into the mathematics curriculum, the role of the teacher and his or her relationship with students will take new direction, with the teacher becoming more of a facilitator of the students' search of understanding, facts and knowledge.

Unanswered Questions Regarding Computer-Assisted Instruction

With over a decade of experience in using computers to assist in mathematics instruction, some questions still create controversy. Questions as to the most effective method of employing the power of the computer remain unanswered.

1. What is the best implementation for computers ?

Papert (1986) did not agree with the current direction computer use is taking. He did not feel that the future lies with the computer being used as a "centralizing force, controlling and managing the education of students. ... I learn something by reading, by playing with it, by getting excited about it, by talking with people about it, by trying all sorts of crazy ideas. " (p. 10) Papert believed that the technology was changing the way people think about education and with experience and time there will be a genuine rethinking of the function that a computer can satisfy.

Research by Ball (1987) in British schools pointed out a variety of roles which the computer can assume (ie. tutorial, diagnostic, simulations), but made only recommendations that computers should be made more available in the classroom.

2. Are computers effective with individuals and small groups ?

Carrier (1988) reported that pairing students in computer-assisted instruction did not lower achievement and that dominant personalities within pairs influenced more selection of a variety of options.

Mevarech (1985) reported that the difference between individualized and traditional computer-assisted instruction was the same as that between noncomputer individualized and traditional instruction.

3. Are there better alternatives than computers ?

Even the most popular role of drill and practice computer-aided instruction has skeptics. In a study using flashcards, Fuson and Brinko (1985) argued that if certain computer techniques (personalized tutoring, immediate feedback with correct response, frequent reinforcement) are replicated, similar achievement can be obtained without the use of technology.

4. Are computers really more efficient ?

A case study by Hativa (1988) included a computer-assisted instruction drill and practice system in arithmetic. The results from that research concluded that the computer enhancement was largely inefficient. Even though the student enjoyed working with the computer the benefits in terms of cognitive learning were small. Rather than move upward in cognitive levels the student was content to regress to simpler computation, whereas the classroom instruction emphasized understanding the procedure used.

Related Research Studies

Research in the area of computer-assisted instruction and achievement in mathematics is made-to-order. These two concepts fit together well due to the nature of acquisition of skills and content involved within the mathematics discipline and the capabilities of computers. Studies have examined a variety of questions and at times yielded conflicting results.

Two variables extensively studied have been cognitive achievement and affective results. Mevarech and Rich (1985) reported maximizing both cognitive and affective outcomes with the use of computer-assisted instruction in elementary school mathematics. In a separate study disadvantaged fifth graders used computer-assisted instruction. That use facilitated acquisition of mathematical skills as well as alleviating math anxiety (Mevarech

1985).

Another concern is whether computer-assisted instruction is most effective with specific ability levels. Goode (1988) reported significant gains of a full year at both high and low ability levels among fifth and sixth graders. Secondary vocational students made significantly higher gains than their control counterparts in knowledge of basic mathematical competencies.

Not all research supports computer-assisted instruction. Cryer-Hittson (1987) found that elementary school Chapter 1 programs complemented with computer-assisted instruction do not produce statistically different achievement. Another research study by Larrea and Peterson (1985) found that computer-assisted instruction with elementary students was only equally as effective as a traditional pull out program where students received special assistance outside of the regular classroom during the instructional day. However, in a similar study, Miller (1984) reported significantly higher achievement by the group exposed to computer-assisted instruction, but he found no significant difference in the amount of retention.

Some mixed results between research studies occur in regard to achievement gains; however, the majority of studies showed higher achievement scores with the intervention of computer-assisted instruction, while others showed equal improvement to control groups. Negative results from computer-assisted instruction are scarce (Hativa,1988).

Chapter 1 Programs Using Computer-Assisted Instruction

Several doctoral dissertations have focused on investigating the use of computer-assisted instruction with Chapter 1 students. Cryer-Hittson (1987) reported that scores in elementary school reading and mathematics do not significantly improve with the use of computer-assisted instruction. Similarly with secondary Chapter 1 mathematics programs, Davidson (1985) did not find significant gains from students being exposed to computer-assisted instruction.

However, Archambeault (1986) suggested that computer interaction time is positively related to measures of mathematics achievement for third grade students. Positive results in mathematics achievement come from a dissertation study involving middle grade students by Miller (1984). In dealing with high-risk ninth grade students, Dellario (1987) stated that achievement data significantly favored the use of computer-assisted instruction for reading and mathematics.

Synthesized Research Reviews

Several studies produce a synthesis of meta-analysis research in computer-based education (Kulik, Kulik, Bangert, & Drowns, 1985; Niemiec & Walberg, 1987; Kulik, Bangert, & Williams, 1985; Kulik, Kulik, Burea, 1985). Niemiec and Walberg (1987) used sixteen reviews of computer-assisted instruction studies. In terms of achievement, computer-assisted instruction moderately raised outcome measures .42 standard deviation points.

The Kulik studies divided analysis in terms of grade level effects. In the elementary school research (Kulik, Kulik, Bangert, & Drowns, 1985), 32 studies were used for the meta-analysis. Positive effects as high as .47 standard deviations were generalized. This was consistent with earlier reviews. (Burns,1981, Hartley, 1978)

The achievement gains, however appear to be inversely related to instructional level. Kulik et al. (1985) found an average difference of .36 standard deviations in secondary school studies and reported a difference of .26 standard deviations in computer-assisted instruction at the college and university level (Kulik et al. , 1986).

The Kulik results may indicate that high school and college students do not necessarily respond as favorably as younger children to the highly structured, highly reactive instruction provided by computer drills and tutorials. Other results from synthesized studies indicated that computer-assisted instruction was significantly more effective in fostering achievement with high achievers and disadvantaged students, but did not provide significant enhancements to average level students (Burns, 1981).

Computer-Managed Instruction Programs

Computer-managed instruction has been getting increased attention. Comprehensive software packages are being developed that allow teachers and administrators to use computers in determining student achievement and skill acquisition in relationship to specified learning objectives. The spotlight on public education coupled with an increase of student populations make computer-managed instruction an attractive option for educational decision makers.

The Montevideo, Minnesota school system used a computer-based measurement system for monitoring elementary student progress through an individualized mathematics and reading curriculum. By keeping track of student progress, data generated on a computer-management system correctly identified with 100% accuracy special education students. (Peterson, Heistad, Peterson, Reynolds, 1985)

With the critical shortage of qualified mathematics teachers, some computer-managed instruction programs were designed to diagnose, prescribe, and deliver instruction. The National Science Foundation funded a project at Arizona State University to develop such a system. The Mathematics Fitness Project was designed to respond to the cognitive and affective needs of reluctant post high school mathematics students. The project developed a hierarchy of mathematics objectives in algebra, general mathematics, geometry, probability, statistics, finite mathematics, and trigonometry. The project offered a significant alternative for upgrading mathematics skills and improving student attitudes toward mathematics. The computer-generated remediation aspect of the program utilized tutorials for reinforcement of diagnosed areas of weaknesses. The program was voluntary and students controlled their own schedules on the computers (Bitter, 1987).

In recent years the use of a computer-based system to measure, instruct, and monitor student achievement has increased. Several companies have developed and marketed similar packages (Clarp, 1988). The initial expense is considerable, but remarkable accomplishments have been reported.

Computer Systems Research Corporation reported an average student gain of 36.1 and 47.0 percentage points on basic skills tests. These results came from two Philadelphia Catholic Schools' Chapter 1 students in grades three through eight. In the South Carolina public school setting, Computer Systems Research show Normal Curve Equivalent gains of 11.2 in reading and 17.59 mathematics in grades one through eight. The secondary school gains were lower but still impressive at 6.44 for reading and 10.90 for mathematics (Computer Systems Research, 1989).

Many of the management systems offer testing, scoring, and analysis. The computer-managed system can generate reports that indicate how well students are mastering learning objectives. The required paperwork for teachers is lessened and time is freed for evaluation of student performance. Teacher can find deficiency areas and adjust the curriculum accordingly.

Summary

This chapter has provided an overview of current and past attempts at incorporating the emerging computer technology in the educational process. The rationale for emphasis on computers as an instructional medium as well as related obstacles of teacher training, appropriate software and cost-effectiveness have been presented. Research, involving the variables of student achievement and attitude in relationship to computer intervention, and their major findings have been discussed.

Research on the impact of computers in education is a rapidly growing field. A body of evidence is being established to help guide appropriate utilization in an educational setting. As the technology is refined and developed numerous questions arise and a constant investigation of educational practices is necessary.

CHAPTER III

METHOD OF STUDY

As reported in the preceding chapter, many research studies have investigated the effect of computer-assisted instruction on achievement. One of the questions which has not been adequately addressed is: "Does varying the administration of a computer-managed component of an instructional program produce observable differences in student achievement ? " The current study involves two approaches toward implementing a computer-managed component in a remedial mathematics program. A method which uses the classroom teacher as the prescriber of courseware for students in the computer-assisted instruction component is compared to an approach which allows the computer management system to prescribe software after administering and analyzing student diagnostic test. A third, control group, was used to investigate the question of whether mathematics achievement was changed by using a computer-assisted component of instruction.

The method of study in this research project was designed to provide evidence as to whether any differences in achievement of basic mathematical skills are evident. Problems encountered in the initial design of the research included: the selection of skills to be addressed, control of initial differences in student achievement, and collecting data on student and teacher attitudes toward the program. This study was conducted in actual classrooms during a regular school session with volunteer participation in providing data. Teacher effect could not be totally eliminated but several constraints of the Chapter 1 mathematics program helped to minimize the differences in teachers. Each of the schools showed similar histories in terms of standardized test scores over the previous years. (ie. CAT Math Total Battery (1986,1988) - School A (67,62), School B (59,55), School C (57,55)) The teachers involved also followed the same curriculum and were provided the same guide for instruction. The text and instructional materials used in each of the schools was also the same. Each teacher also experienced the same staff development and participated in similar training in the use of the materials. Students from each of the schools were also selected for participation in the Chapter 1 remedial mathematics program using the same criteria. In this manner differences between teachers was minimized.

Research Design

The structure for this research project involved three groups of middle school students. The sample included seventh and eighth grade students from three schools. The treatment in Group A involved a pretest, computer-assisted instruction with teacher assignment of courseware, and a posttest. Group B received a pretest, computer-assisted instruction with no teacher decisions on courseware, and a posttest. Group C had a pretest, typical classroom instruction without any computer intervention, and a posttest. Further definition of the sample will follow in Chapter IV.

The study was designed with a statistical analysis of pretest and posttest data to focus on determining and comparing achievement of basic mathematical skills for each of the three groups.

The study was designed for a one semester duration. Test data is collected at the beginning of the semester and at the end of the semester. The testing instrument is the Phase Two and Phase Three forms of the Minimum Skills Diagnostic test used in pretest and posttest respectively. (see appendix B)

In addition to traditional classroom instruction the students in Group A were given computer interaction two days per week. The content presented in a tutorial manner was selected by the teacher to correlate with classroom instruction. Individualization was maintained while students worked at their own pace on related topics. The teachers monitored progress and provided guidance during the computer lessons. The teacher's role in the computer role was more as that of a facilitator rather than an instructor.

The students in Group B also received computer-assisted instruction two days per week along with typical classroom instruction. However, content was assigned by the computer management system. Students in Group B went through a series of diagnostic tests and were prescribed courseware according to the results of their performance on the diagnostic tests. The teachers for Group B were also present for the computer lab sessions and facilitated students computer activities. The teachers provided individual attention and assistance for students involved in software instruction. Progress was monitored by the teachers, but the presentation of software was decided by the computer management system.

The students in Group C did not receive any computer time as part of its instructional program. The classroom instruction in each group was guided by system-wide objectives and curricular guide. The instructional materials are the same for each group with the exception of the computer-managed component.

Student attitude was evaluated through a structured interview process. (see appendix C) A sample of twenty-five student participants from each group answer questions designed to ascertain student reaction to the use of computers in their mathematics instruction. A sample of students is selected by each teacher from poor, average, and better students in the class.

Each teacher also participates in the interview process to analyze her reaction to the computer-assisted component of the mathematics instruction program. (see appendix D)

Selection of the Sample

The sample selected for the study was composed of students attending three middle schools in a consolidated school system of Piedmont North Carolina. A more detailed description follows in Chapter IV. The school system is the fourth largest in the state and has twelve middle schools, not including an optional center for middle grades. Students from five classes in each school, three seventh grade and two eighth grade, comprise the sample.

The three middle schools (grades six, seven, eight) are each located in an urban setting with over forty percent minority population. This is above the average of the total school system where the make up is only thirty-seven percent minority. Two of the schools have networked labs of computers and are supplied with the software chosen for the computer-assisted component of the study. The third school also contains a computer lab, but networking and the management system and courseware used in the study are not available.

The schools are not selected on a random basis, but rather on the basis providing an appropriate environment for a project involving a computer-assisted instructional program. The selected schools are, however, matched in population and previous testing data. Statistical analysis of variance from the pretest scores indicates no initial differences between the sample populations of the schools. Specifics of the pretest analysis are discussed in Chapter IV.

The students are enrolled in a Chapter 1 remedial mathematics class. The selection of Chapter 1 participants is based on points accumulated from four criteria: (1) achievement on California Achievement Test (one to three points) (2) teacher recommendation [zero to three points] (3) achievement on a local mathematics placement test (one to three points) (4) achievement in an individualized computational skills program [one to three points].

Description of the Setting

The school system selected for this research is located in Piedmont North Carolina. It is a system which has consolidated all schools in the county under one administration. There are forty-nine schools with a total student population of approximately 38,300. The pupil-staff ratio is 1 to 13.27.

The financial budget is approximately $ 150 million with a per pupil expenditure of $ 3850.20. With an above average tax base from which to draw, it is considered one of the wealthiest in the state. This wealth allows for more funds to be allocated for computer equipment to be used for instructional purposes. Teachers also receive one of the largest yearly supplement in the state.

Three of the system's twelve middle schools were used in the study. The middle schools involved in the study are all over twenty years old and each was designated as a junior high school in previous years. The school system changed to a middle school (grades six, seven, and eight) concept in 1983. The three schools had minority populations which comprised 40, 45.8, and 46.7 percent of the total student body. Each school was located in an urban setting with subsidized housing in the surrounding neighborhoods. The three schools were each within a mile and a half of each other. White students were bused from other neighborhoods to balance racial populations. The three schools also had a high percentage of low income families, as indicated by thirty to thirty-six percent of the students participating in the free or reduced meal program. Another factor of similarity is that each has enough students qualifying for the Chapter 1 mathematics program to support at least five sections of the remedial classes.

Research Procedures

The associate superintendent for the school system was approached and a request to do research was filed (see Appendix D).

In order to use the Mathematics Skills Diagnostic Test the researcher had to get the project approved by the director of Chapter 1 programs. After all clearance was obtained, the study was explained to and cooperation requested of the principals of each of the three middle schools. When administrative support was offered the researcher visited with participating teachers at each school. Teachers were apprised of the logistics involved in the research effort. Safeguards to assure data security and protection of anonymity were discussed and agreed upon. The training for the teachers using the computer-assisted component of the program was completed prior to the students' first day at school. The researcher's only contact with the teachers was for distribution of pretest and posttest materials and interview sessions.

Measurement of Achievement Gains

The mathematics portion of the North Carolina Minimum Skills Diagnostic Test, Phase 2 and Phase 3, was selected as the reference for the pretest and posttest respectively. In 1984, the North Carolina State Department of Public Instruction, Research Division, developed the Minimum Skills Diagnostic Test to indicate mastery of the basic competencies established by the North Carolina State Board of Education. The test is meant to assess an individual's degree of mastery on mathematical skills necessary for successful performance in their future schooling. The test is designed to be objective-specific and concentrate directly on objectives designated by the Basic Education Program.

The tests used in Phase 2 and Phase 3 are identical in objective coverage and intended to provide summary information in evaluating an instructional program. Each test consists of one hundred multiple choice items. Sample problems from the tests can be found in appendix B.

The tests were constructed, field tested, and analyzed for validity in the areas of curriculum, instruction, and content. The alpha reliability coefficients from the first test of record, May 1986, range from .88 to .97.

Computer Configuration for the Computer-Assisted Component

The two schools receiving the computer-assisted component in instruction had classrooms converted to house twenty-five IBM personal computers. Each lab had their computers situated around the walls of the room so that the students' backs would be toward the center of the room when using the computers. The computers are situated next to each other with a minimal amount of room between them. The lack of desk top space allowed for some interaction between students.

The twenty-five workstation computers are all linked with baseband cabling in groups of seven. Each group in turn is connected to the file server, an IBM Personal System II Model 60. The file server is equipped with two seventy megabyte hard disks to store the courseware as well as student records.

In addition to the computer, a printer is also linked to the server. This is used to print hard copies of student reports. Teachers can either bring individual student data up on the monitor or have it printed out.

Computer Management System and Courseware

The software chosen for use in this study was developed by Computer Systems Research, Inc. , Avon, Connecticut. Computer Systems Research has been involved in education since 1974. Originally the software was developed for a school system in

Florida, but now is marketed in close association with hardware developers nationally.

Accompanying the software but, purchased separately is a management system with diagnostic and prescription capabilities. The administration of software can be accomplished by two separate means. The first method of course assignment is for the system administrator to develop a strand or sequence of courses and manually assign students a given sequence. Students are not required to take a diagnostic test, but, because each module incorporates a pretest the student does not spend time working on skills which have been previously mastered.

The second method is done automatically by the computer management software. A student is assigned a series of diagnostic tests which are subsequently scored by the computer. An individual skill is addressed in three questions within the diagnostic test. If a student cannot correctly answer two of the three questions , the student is assigned a software module which pertains to that skill. Hence, a series of modules or courses will automatically be assigned based on the performance on diagnostic tests administered and scored by the computer.

Individual skills are presented in separate modules or courses. Each course has the same basic format. The modules are designed to diagnose student knowledge in a specific skill, train the student in the skill through exacting interaction, and assess the exit level skill. Each course begins with a ten question pretest. This serves as a screening process for students who have mastered the skill or were incorrectly placed by the diagnostic testing process. If a student cannot perform accurately on eight or more questions, he or she is channeled through an interactive tutorial section to learn the specific skill. Upon completion of the tutorial, a ten question posttest is administered. The same eighty percent criteria is used to determine whether the student moves to the next module or repeats the current one. If a student is unsuccessful on the posttest on a second try, he or she moves to other courses but will be assigned the course once more when all current assignments are completed.

The management system is not only used in instructional delivery, but handles additional administrative matters such as tracking student progress and producing reports on student achievement. The system along with the basic skills curriculum software, is designed to be a complete instructional management package that is highly automated. The management system is responsible for tracking each students progress through a program which has been specifically selected for him or her. A nice feature of the management system is immediate updating of student records when interaction is terminated. Reports range from a simple summary of what modules have been completed to a detailed report of each key stroke made by the student with the time the stroke was made. (see appendices E,F,G)

Teacher Training

The teachers involved with the study and using the computer-assisted component received ten hours of introduction and training on the computer network, management system, and courseware. There is a similar program for language arts and those teachers received training concurrently but were not involved in the study. Teachers were introduced to the network and the procedure for logging in and logging off. The basic configuration of workstations was covered, but both schools have a system operator to handle file maintenance and student registration.

The management system was explained with its capabilities of diagnosis and prescription. Teachers were given a variety of examples of sample reports available for tracking student progress and assess achievement. Teachers were presented ways in which the management system attempted to individualize a student's course of study based on his or her previously acquired skills. The system operator's responsibilities were explained but not covered in detail.

The teachers spent several hours reviewing courseware content. The aim was to get teachers familiar with the content students would be exposed to as part of the computer-assisted component of instruction. The teachers were able to experience first hand the format of concept and skill presentation as well as branching capabilities based on user response.

Data Collection Procedures

The testing procedure for obtaining both pretest and posttest data was identical. In each school one class set of test booklets was issued. No two classes were concurrently scheduled, thus only one set of test booklets could be passed from teacher to teacher.

Each teacher was responsible for administering the test to his or her class. Testing of students covered two fifty minute periods on consecutive days. Students missing all or any portion of the test were administered make-up tests at the first available time.

Pretests were given at the beginning of the fall semester before students were introduced to the computer-assisted component of instruction. The posttest was administered at the close of the semester. Sample questions can be found in Appendix B.

Answer sheets were accumulated and scored by computer. Data on pretest and posttest were analyzed with assistance of a microcomputer statistical program called Microstat.

Data Analysis

An analysis of variance was conducted between the pretest scores for each school. The results indicated that no school's pretest means differed significantly from either of the other two. A more detailed description of the results can be found in Chapter IV.

A certain amount of progress is expected in the normal course of any instructional program. The regression analysis is an attempt to predict what score would occur on the posttest without any special intervention. The residual, the difference between the predicted and actual score, gives a more accurate representation of achievement gains.

The regression equation is obtained from past performances on the North Carolina Minimum Skills Diagnostic Test. The researcher did not collect data necessary for computing a regression equation. The data for the regression equation was supplied by the State Department of Public Instruction, Research Division. The data consisted of results from the administration of the test in 1987.

Since group means showed no significant differences on the pretest the analysis of posttest data can be used to assess whether treatment with computer-assisted instruction makes a significant difference. Analysis of variance was again computed between each group posttest mean.

The interview data for both student and teacher responses were organized by specific topics outlined and addressed in the questions. (see Appendix C) Results were tallied and reported in percentages in Chapter IV.

Summary

The method of study in this research project was a pretest and posttest data analysis to designed to compare and determine the effectiveness of two different administrations of a computer-assisted component for a remedial mathematics program. The criterion measure selected was the mathematics portion of the North Carolina Mathematics Skill Diagnostic Test. This test was selected for its relationship to the objectives for the mathematics curriculum proposed by the North Carolina Department of Public Instruction's Basic Education Program. The objectives of the remedial mathematics program involved in the study correlates closely with the objectives of the state Basic Education Program. The North Carolina Mathematics Skill Diagnostic Test was also designed and constructed to evaluate the effectiveness of a school program. Chapter IV reports the results and conclusions of data analysis.

CHAPTER IV

REPORT OF THE FINDINGS

The data collected for this study consisted of numerical scores on pretest and posttest instruments and information from individual interviews. Data for 173 students who were administered both the pretest and the posttest were used in the statistical analysis. Due to the unavailability of a pretest or a posttest score, 72 students had their data omitted.

All six teachers involved in the study were interviewed. In addition, each teacher selected five students from each class to be interviewed.

Statistical procedures were employed on the test data to test the first hypothesis. The results of data analysis will follow in this chapter.

An analysis of variance for the pretest scores was conducted to verify initial homogeneity of mathematics skills for students in each of the three groups. The analysis of variance procedure assists in determining whether differences among two or more means are greater than would be expected from sampling error or chance. The analysis of variance reduces the probability of rejecting a true null hypothesis (type-1 error) over making individual t-tests for pairs of means. The power of the analysis of variance is such that if enough evidence does not exist to reject the null hypothesis, generally, no further analysis is necessary.

When statistically significant differences among separate means are found through use of the analysis of variance, a search for which differences actually cause the null hypothesis to be rejected is undertaken. This is accomplished through a method of multiple comparisons, such as the Sheffe method. The Sheffe method was selected in this study because of its flexibility in dealing with groups that do not contain the same number of data points.

The study also included analysis of affective data reported through a structured interview process with both student and teacher participants. The interview data were categorized and responses were tallied separately for students and teachers. Each response was coded into specific classifications. The numbers were reported in percentages of respondents making similar comments.

Description of the Sample

The sample for the study was taken from middle school students in a piedmont North Carolina school system. The sample was comprised of seventh and eighth grade students enrolled in fifteen Chapter 1 remedial mathematics classes of three of the school system's twelve middle schools. Two of the schools had been targeted for use of the computer-assisted component of the study.

Two groups of students received separate treatments involving computer-assisted instruction while a third group served as a control with no computer intervention in its instruction. The sample was nearly equal in distribution among the three groups.

Table 1
Sample Distribution

	Group							
	A			B			C	
	#Classes	N		#Classes	N		#Classes	N
7th gr.	3	33	7th gr.	3	34	7th gr.	3	32
8th gr.	2	25	8th gr.	2	26	8th gr.	2	23
Total	5	58		5	60		5	55

The variance between the number of seventh and eighth grade classes was due to the nature of enrollment in Chapter 1 programs. Some seventh grade students will gain enough skills during the year to progress out of the Chapter 1 program in the eighth grade and, therefore, fewer classes are formed.

Description of the Teacher Sample

Six teachers, two from each school, were involved in the study. Each teacher is certified by the state to teach middle school mathematics. Every teacher had been at his or her present school for five years (ever since the school system reorganized into middle schools). The experience of the teachers ranged from ten to thirty years. Experience teaching in the Chaper 1 program ranged from four to thirty years.

Pretest Data

The pretest, North Carolina Minimum Skills Diagnostic Test (Phase 2), consisted of a one hundred item instrument. Sample items are in appendix B. The instrument for pretest and posttest was selected because the design of the test fit the basic education program addressed by the curriculum. The test was developed with 29 objectives (appendix A) that closely paralleled those of the stated curriculum. Each objective was tested by three or four items on the test. Scores were tabulated at the rate of one point for each correct response. For the whole sample the minimum score on the pretest was 16 while the maximum was 83.

The grouped frequency distribution showed the clustering of individual scores and indicated the normality of score distribution. (table 3) Group A and Group B appeared to have more scores in the higher ranges indicating a negative skew. This was confirmed by a moment coefficient of skewness statistic equal to -.99746 and -.64623 respectively. A negative skew will have the mode and median higher than the mean due to a large number of high scores. The coefficient of skewness is affected by the size of the difference between the mean, mode and median. Group B was closer to a normal distribution with most scores clustered around the interval containing the mean (between 50 and 60). The moment coefficient of skewness for this group was -.06323.

The large number of high scores from Group A and Group C also caused the shape of the distribution to be more slender and narrow than a normal curve. This peaked or leptokurtic condition was reflected in moment coefficients of kurtosis of 3.5875 and 2.9228 respectively. The coefficients for kurtosis indicate the shape of the curve in relation to a normal curve. Even Group B with scores clustered around the mean was leptokurtic or narrow and slender with a moment coefficient of kurtosis of 2.1068. The interval from Group B with the largest number of scores was higher than the interval containing the mean and, therefore, a higher positive moment coefficient of kurtosis was produced.

Table 4 shows the descriptive measures on the pretest for each of the three groups. These statistics include measures of central tendency as well as measures of variability. Table 4 is a good picture of scores from the sample. The mean describes the achievement of the typical or average individual within the group. The standard deviation clarifies the differences among the scores and illustrates the spread or variance of the scores in the sample.

The standard error of the mean is reported to indicate how good a representation the sample is for the population it represents. It tells how much the means would differ if other samples were used.

Table 2
Pretest Grouped Frequencies

Group A

--Class		Limits--	Frequency	Percent	···Cumulative··· Frequency	Percent
20.00	to	29.00	1	1.75	1	1.75
30.00	to	39.00	4	7.02	5	8.77
40.00	to	49.00	10	17.54	15	26.32
50.00	to	59.00	12	21.05	27	47.37
60.00	to	69.00	21	36.84	48	84.21
70.00	to	79.00	9	15.79	57	100.00

Group B

--Class		Limits--	Frequency	Percent	···Cumulative··· Frequency	Percent
20.00	to	29.00	0	0.00	0	0.00
30.00	to	39.00	6	10.00	6	10.00
40.00	to	49.00	15	25.00	21	35.00
50.00	to	59.00	9	15.00	30	50.00
60.00	to	69.00	18	30.00	48	80.00
70.00	to	79.00	10	16.67	58	96.67
80.00	to	89.00	2	3.33	60	100.00

Group C

--Class		Limits--	Frequency	Percent	···Cumulative··· Frequency	Percent
20.00	to	29.00	2	3.64	2	3.64
30.00	to	39.00	2	3.64	4	7.27
40.00	to	49.00	9	16.36	13	23.64
50.00	to	59.00	16	29.09	29	52.73
60.00	to	69.00	21	38.18	50	90.91
70.00	to	79.00	5	9.09	55	100.00

The closeness of the means between the three groups was obvious. The largest difference (0.666) occured between Group A and Group C. The analysis of variance for the pretest means (table 5) indicated that statistically the group means were equal. The analysis of variance compares the variation of scores among sample score to the variation of scores within each of the samples. The sum of squares indicates the variance of scores but must be

Table 3
<u>Descriptive Statistics for the Pretest</u>

	Group		
	A	B	C
N	58	60	55
min.	16	32	28
max.	73	83	75
mean	56.79	56.58	56.13
std. dev	13.12	12.37	10.85
std. err. mean	1.72	1.60	1.46

adjusted by the degrees of freedom (dF) since the size of the sample will affect the size of the sum of squares. In order to reject the null hypothesis, (the means are equal) the variation among sample averages must be considerably larger than the variation within the samples. An F-statistic is generated to represent that difference.

The computed F ratio (.044) is so small that the null hypothesis cannot be rejected. With the means being statistically equal on the pretest, any direct investigation of the posttest scores will produce the same results as comparing residual gains.

Table 4

One-Way Analysis of Variance for Pretest Means

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	13.027	2	6.514	0.044	.9570
Within	25206.210	170	148.272		
Total	25219.237	172			

Posttest Data

The posttest, North Carolina Minimum Skills Diagnostic Test (Phase 3), was administered at the close of the semester. The instrument for representing student achievement was designed to be parallel to the pretest. There were one hundred multiple choice items. The score was determined by calculating one point for each correct response.

The grouped frequency (table 6) for the posttest did not follow the same pattern as the pretest data. Group A and Group C were still negatively skewed, but the severity had dropped. The moment of skewness for Group A was -.3704 and for Group C it was -.5304. Group B, whose pretest scores were closest to a normal distribution, recorded the highest moment of skewness with a moderate -.5068.

The kurtosis for each group remained leptokurtic (slender and narrow). This is not surprising with a high correlation between the two tests. The moment coefficients of kurtosis turned out to be: 2.4021 for Group A, 2.737 for Group B, 2.6228 for Group C.

The descriptive statistics (table 7) showed an increased mean for each group. Group A had the largest mean (70.1379) which was a gain of over 13 points. The variation between scores was reduced producing a standard deviation of 9.8967. Group B's mean increased over 9 points to 65.0500. The variation between scores widened to produce a standard deviation of 16.0431. Group C also had a wider spread of scores with a standard deviation of 13.1606.

Table 5
Posttest Grouped Frequencies

Group A

--Class		Limits--	Frequency	Percent	···Cumulative··· Frequency	Percent
20.00	to	29.00	0	0	0	.00
30.00	to	39.00	0	0	0	.00
40.00	to	49.00	1	1.72	1	1.72
50.00	to	59.00	10	17.24	11	47.37
60.00	to	69.00	11	18.97	22	37.93
70.00	to	79.00	28	48.28	50	86.21
80.00	to	89.00	8	13.79	58	100.00

Group B

--Class		Limits--	Frequency	Percent	···Cumulative··· Frequency	Percent
20.00	to	29.00	2	3.33	3	3.33
30.00	to	39.00	2	3.33	4	6.67
40.00	to	49.00	5	8.33	9	15.00
50.00	to	59.00	15	25.00	24	40.00
60.00	to	69.00	8	13.33	32	53.33
70.00	to	79.00	16	26.67	48	80.00
80.00	to	89.00	9	15.00	57	95.00
90.00	to	99.00	3	5.00	60	100.00

Group C

--Class		Limits--	Frequency	Percent	···Cumulative··· Frequency	Percent
20.00	to	29.00	0	.00	0	.00
30.00	to	39.00	7	12.73	7	12.73
40.00	to	49.00	4	7.27	11	20.00
50.00	to	59.00	9	16.36	20	36.36
60.00	to	69.00	21	38.18	41	74.55
70.00	to	79.00	10	18.18	51	92.73
80.00	to	89.00	4	7.27	55	100.00

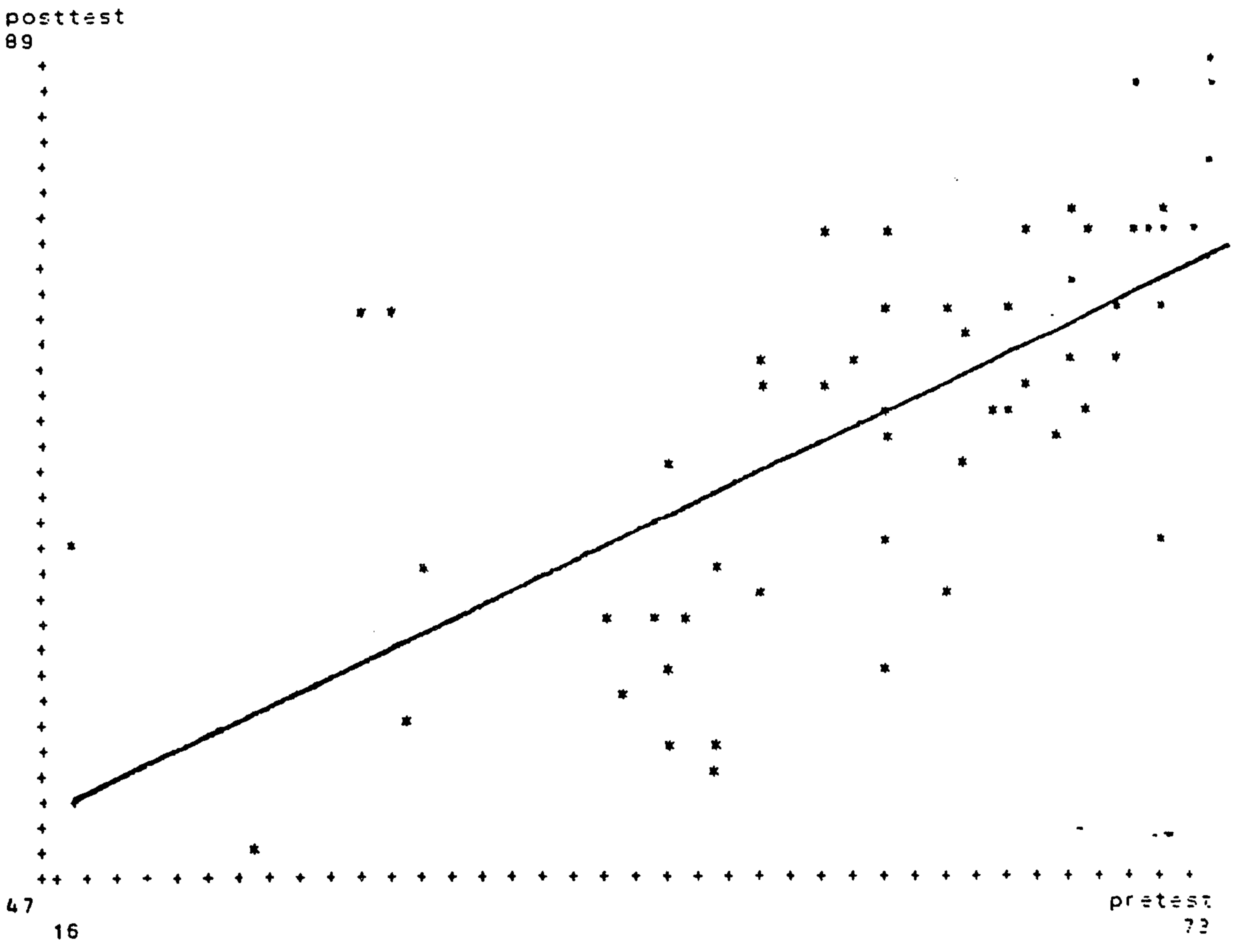
Table 6
Descriptive Statistics for the Posttest

	Group		
	A	B	C
N	58	60	55
min.	47	23	33
max.	89	90	82
mean	70.14	65.05	61.16
std. dev	9.90	16.18	13.26
std. err. mean	1.30	2.09	1.79

The scatter diagram is a graph between the two variables, pretest and posttest (figure 1, figure 2, figure 3). The scatter diagram helps to understand the nature of the relationship between the two measures with a visual representation. Each point of the graph represents an individual's score on each test. Pretest scores are measured on the horizontal axis while values for the posttest are shown on the vertical axis. Each group is represented by a rough linear relationship. The points move up and to the right. This means that students who scored high on the pretest also scored high on the posttest. The regression line depicted in each diagram gives a close representation of how the scores match.

FIGURE 1

SCATTERGRAM (pretest vs posttest) - GROUP A

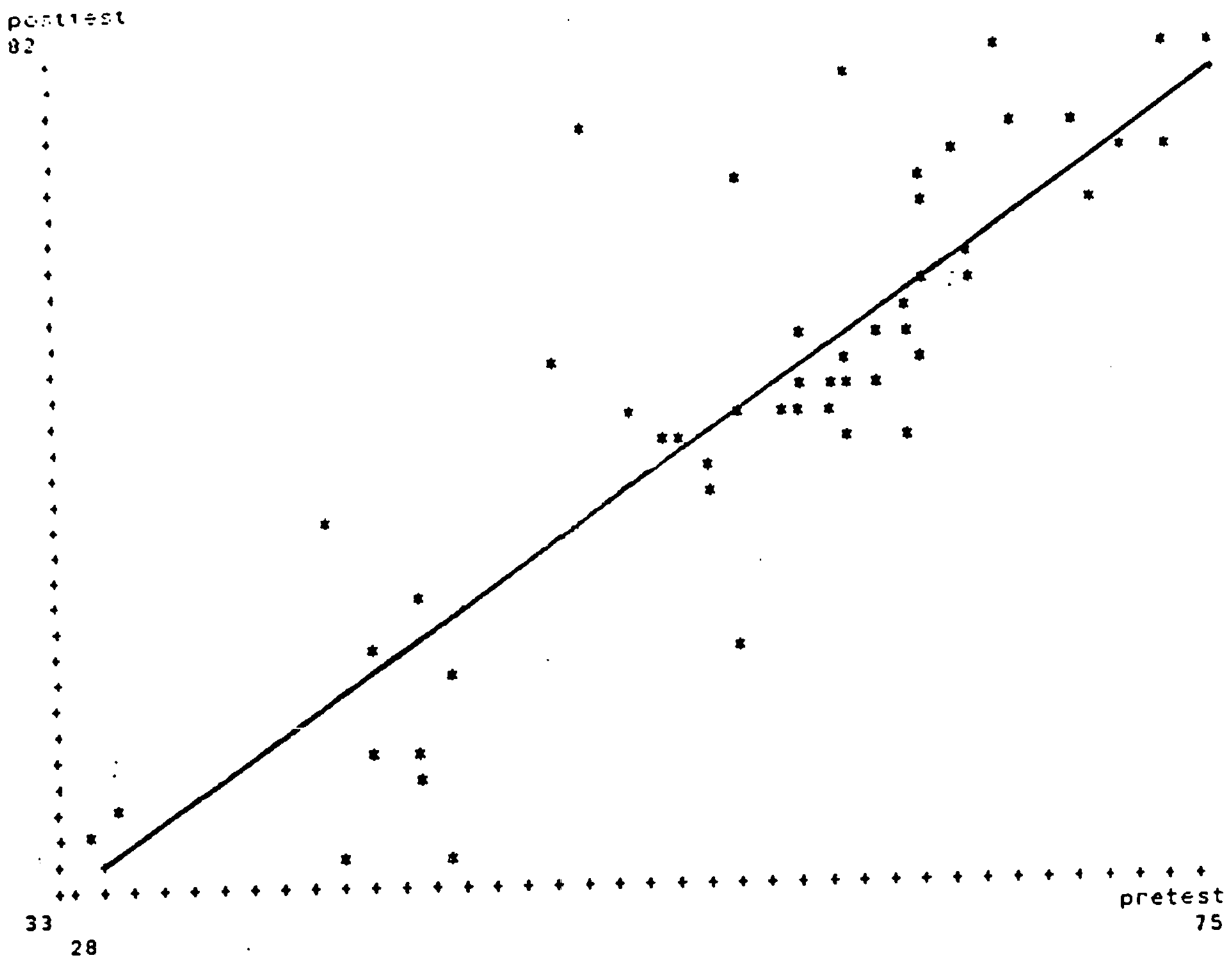


Scatterplot Pretest X Posttest

REGRESSION EQUATION (Shown by +'s on scatterplot):

FIGURE 2

SCATTERGRAM (pretest vs posttest) - GROUP B

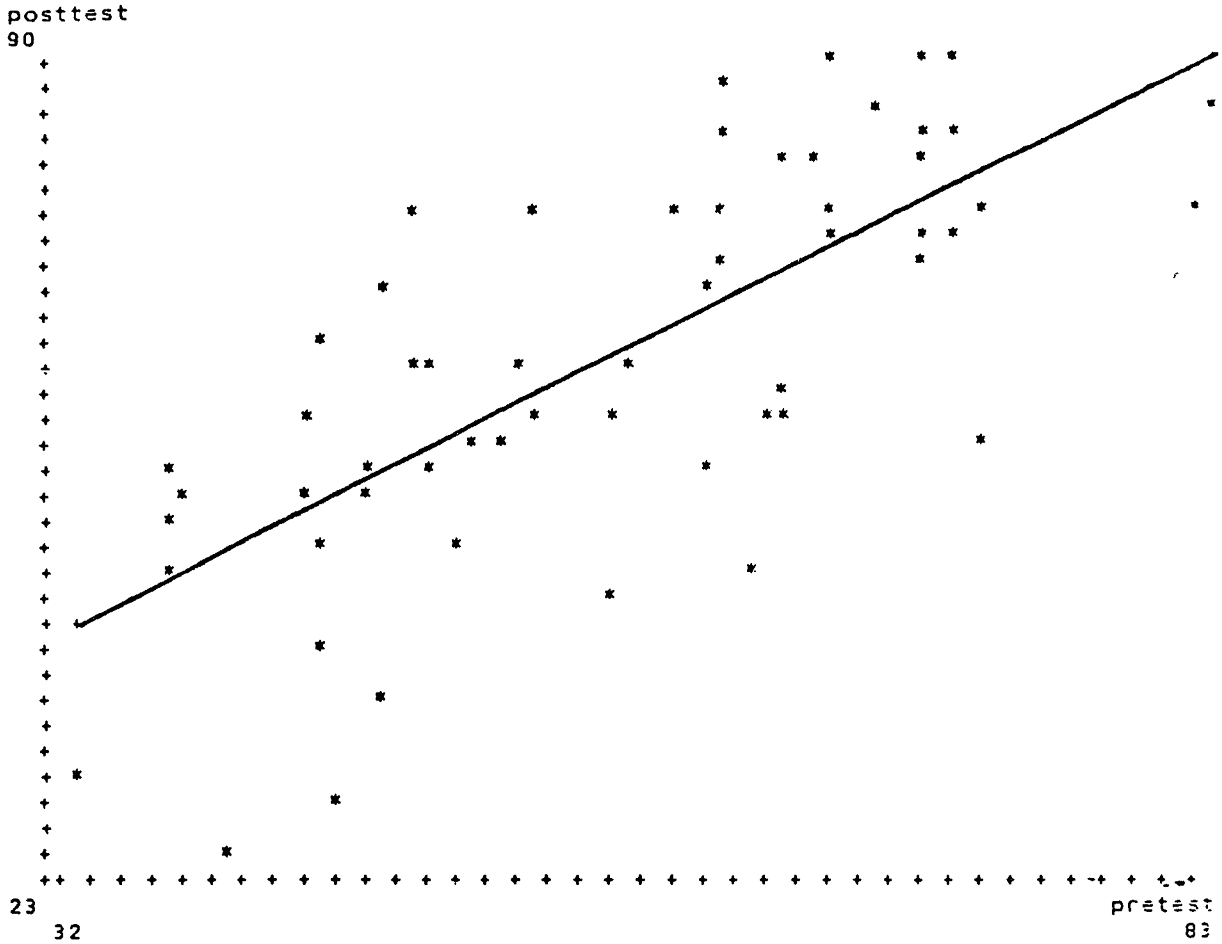


Scatterplot Pretest X Posttest

REGRESSION EQUATION (Shown by +'s on scatterplot):

FIGURE 3

SCATTERGRAM (pretest vs posttest) - GROUP C



Scatterplot Pretest X Posttest

REGRESSION EQUATION (Shown by +'s on scatterplot):

The correlation matrix for each of the groups, depicted in Table 7, provides a statistical representation of the degree to which the pretest and posttest are related. The correlation coefficient summarizes the magnitude of how the two variables relate to each other. All three correlation coefficients (Group A .6536, Group B

Table 7
<u>Correlation Matrix (Pretest vs Posttest)</u>

Group A (n=58)		
	Pretest	Posttest
Pretest	1.00000	
Posttest	.65357	1.00000

Group B (n=60)		
	Pretest	Posttest
Pretest	1.00000	
Posttest	.72345	1.00000

Group C (n=55)		
	Pretest	Posttest
Pretest	1.00000	
Posttest	.85569	1.00000

.7234, Group C .8557) indicated a relatively strong relationship between pretest and posttest scores. This is visually evident in the scatter diagrams with few points differing substantially from the regression line. This relationship was not surprising since the two evaluation instruments were designed to parallel each other.

The results of the analysis of variance between group means on the posttest are displayed in Table 9. As mentioned in the analysis of variance for pretest scores, the critical value is a comparison of the variation between groups and the variation within groups. With the sum of squares between (2293.905) being substantially smaller than the sum of squares within (30521.274) a large F-ratio (6.388) was produced. This indicated that differences

Table 8

One-Way Analysis of Variance for Posttest Means

Source	Sum of Squares	dF	Mean Square	F Ratio	Prob.
Between	2293.905	2	1146.953	6.388	0.002113
Within	30521.274	170	179.537		
Total	32815.179	172			

between the means were statistically significant. This indicates that at least one mean is significantly different from the others.

Since differences between means was indicated a multiple comparison analysis is appropriate. This helped to find which differences in means were significant. The Sheffe method of multiple comparisons was used. The Sheffe method is a versatile, flexible post hoc multiple comparison. The results of the Scheffe method of comparison appears in Table 10.

Each of the comparisons produced significant differences with some being stronger than others. The largest difference between posttest means was found between Group A and Group C. The critical value produced by the Scheffe test was at an alpha level less than .001. Between Group A and Group C a high critical F-ratio set the alpha level less than .025. The third comparison between Group B and Group C provided the smallest of the alpha levels at less than .10.

The data collected showed gains in mathematics achievement for all three groups. The largest gains were reported by Group A. Statistical analysis showed significant differences between group means on the posttest.

Table 9

Scheffé Multiple Comparison of Posttest Means

Group A vs Group B	
F-ratio = 4.252433	$p<.025$
Group A vs Group C	
F-ratio = 14.034579	$p<.001$
Group B vs Group C	
F-ratio = 2.4136135	$p<.10$

Interview Data

Qualitative data was collected via a personal interview process. The student interviews were conducted according to a structured outline of questions (appendix C). During the introductory questions, responses were marked in one of five categories. The categories ranged from a strong positive or an always response (A) to a negative or never response (F). The summary questions consisted of students making specified preferences or choices among a group of items.

General feelings about school were mixed and no identifiable differences between groups were present. When asked whether a student enjoyed school, only 36% had a positive response, while 45% responded negatively. When the specific subject of mathematics was addressed, 56% made a positive comment with only 28% giving negative comments. However, the majority of the students (69%) indicated a difficulty in learning mathematics.

Students in Group A and Group B (those using the computer-assisted component of the curriculum) were also asked several questions on their computer experiences. When the topic of computers was introduced, 68% responded enthusiastically about using computers in school. An equal number felt that they could learn from software programs on a computer.

When the topic was narrowed to specific software used in the study, students' positive response rate was slightly higher at 69%. Group A and Group B students indicated a positive reaction to the total computer component of their mathematics instruction at a rate of 58% with only 22% having negative feelings.

Group A and Group B students were asked whether they would like more or less time using the computer software. The majority (57%) desired to have more time than the schedule which allotted two periods a week. The dissatisfied students (19%) wanted less contact with the computers. When given a choice of activities to learn mathematics, the top three responses were as follows: (1) work on a computer - 46%, (2) use worksheets - 17%, (3) use a textbook - 15%.

Just over half of the students (53%) reported using computers in the previous year. A resounding 88% felt that computers should be incorporated in subjects other than mathematics. When asked about a computer lab environment, 71% reported it conducive to learning.

Teacher interviews were conducted in a similar manner. The initial questions were dichotomous with the latter part of the discussion designed for free response. Four of the six teachers indicated having previously used computers as part of their instruction. Half of the teachers believed that the most effective way to teach mathematical concepts is through demonstration, while one-third indicated that a combination of techniques was important. All of the teachers felt that students enjoyed using computers in their learning, but two included reservations in some circumstances.

The teachers of Group A and Group B (the groups involved in the computer-assisted instructional component) added specific insights toward the computer labs and software that were used in the study. Student management in the labs was not a concern. Only one response was negative when making inquiry about tracking student progress. That teacher felt that she had to rely on the lab administrator to get printed reports. All but one teacher felt that a full period (fifty minutes) was too long for students to sit and work in front of a computer monitor without a break.

An interesting result occured from questions concerning control of the software The teachers in each group were split between preferring teacher decisions on software assignments and having the computer's diagnostic process assign the software.

Only one teacher responded negatively toward the ability of the Computer Research System software to effectively provide mathematics instruction. The rest of the teachers felt that students were learning the concepts presented in the software .

Comments on positive aspects of using computers as part of instruction included the following: "provides individualization," "supplements and complements the textbook," "gives students exposure to topics not covered in the classroom." The negative comments included: "students are discouraged when failures occur," "directions are not always clear," "students become bored after a while."

Teachers recommended using a variety of software. They felt that students easily lose interest if they are taken through the same procedure and routine over and over again. They also recommended arranging the computers in a manner that would cut down on student distractions. Making more room for each workstation was the most often mentioned remedy along with making individual cubicals for the computers.

Summary

This chapter includes results from both numerical data and statistical analysis as well as personal interview data. Student achievement between the three groups was compared. The feelings of students and teachers about the use of computers in mathematics instruction were reported.

In general, the data favors the groups involved with the computer-assisted component in their mathematics instruction. In particular, the group which had teacher input into the assignments of software topics showed higher achievement gains. Higher achievement was indicated as well as positive feelings toward the ability of computers to assist in teaching mathematical concepts.

CHAPTER V

DISCUSSION OF RESULTS

Summary

The objective of the study was to provide evidence and insight on what effect the style of administration of computer-assisted instruction has on student achievement. The present study involved two separate implementations of a computer-managed component in a remedial mathematics program. One method of implementation involved the teacher determining which software would be presented to the students. The second method of implementation utilized the diagnostic and prescriptive capabilities of the computer management system to assign appropriate software for the students. A third, control group was used to compare achievement of students who were not using the computer-assisted component of instruction.

The study was conducted during the fall semester (eighteen weeks) of the 1988-89 school year. Data on 173 students in three middle schools were collected on pretest and posttest scores to determine student achievement. Additional qualitative data were collected through a structured interview process with 75 students and six teachers. Results from the data collection were presented in the previous chapter.

The results described in the preceding chapter reveal that the treatment groups receiving a computer component in mathematics instruction experienced more success than the control group. The findings point to the conclusion that computers can effectively provide instruction to remedial mathematics students.

The purpose of this chapter is to utilize the data to investigate the hypotheses stated in the first chapter. Conclusions will be drawn from the data, recommendations will be proposed, and suggestions will be made for further study.

The present study was designed to compare effects of two administrations of a computer-managed instructional package and determine their effectiveness in terms of achievement for a Chapter 1 remedial mathematics program. Student achievement gains in mathematics were based on differences between scores on a pretest and a posttest. An analysis of variance was used to determine if significant differences were produced by the two administrative procedures used to deliver the software.

H_1: Students whose computer-assisted component of mathematics instruction is assigned by the teacher to parallel classroom instruction will demonstrate statistically significant higher gains in mathematics achievement than those students whose computer assignments are made by the computer and not aligned with classroom instruction.

The directional hypothesis purporting that students who received computer-assisted mathematics instruction with teacher prescribed software would show higher achievement gains than students who received computer prescribed software remained tenable. The multiple comparison procedure between posttest means for Group A and Group B ($F= 4.252$) showed Group A achievement significantly higher at the $p< .025$ level.

The second hypothesis focused on differences between students exposed to computer-assisted instruction and those who did not receive any computer interaction in their instruction.

H_2: Students who receive a computer-assisted component in mathematics instruction will demonstrate statistically significant higher gains in mathematics achievement than students not receiving any computer interaction.

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H_2: Students who receive a computer-assisted component in mathematics instruction will demonstrate statistically significant higher gains in mathematics achievement than students not receiving any computer interaction.

The hypothesis that students receiving computer assisted mathematics instruction (Group A and Group B) would show significant gains in mathematics achievement over those students receiving no computer contact (Group C) remained tenable. Results form the analysis of variance between group posttest means ($F= 6.388$) indicated significant differences at the $p< .01$ level of a directional hypothesis with 172 degrees of freedom. Further multiple comparison analysis showed the largest difference ($F= 14.035$) between Group A and Group C, significant at the $p< .001$ level. Differences between Group B and Group C were also high ($F= 2.414$) with a significance level of $p< .10$.

The third hypothesis emphasized the impact on computer-assisted instruction would have on students' attitudes.

H_3: Students who receive a computer-assisted component in mathematics instruction will report positive attitudes toward use of computers in learning mathematics.

The hypothesis that students involved in the computer-assisted instruction would report favorable attitudes toward using computers in their educational experiences remained tenable.

Positive attitudes were evidenced by a favorable response from 58% of those interviewed compared to a negative response from only 22%. In addition, 57% wanted to spend more time with computers and 88% wanted to have exposure in other content areas.

Conclusion

Previous studies on achievement from computer-assisted instruction have been generally favorable. The results of this study reflect similar conclusions. Both groups using the computers showed significant differences in posttest scores. The students who received computer-assisted instruction were better able to perform basic computational problems as well as answer conceptually oriented questions. This is an indication that they were able to develop more skills necessary in basic mathematics. Their performance suggested that computer experiences were effective in the learning of mathematical skills.

In no way does this study address the issue of causality. The pretest and posttest combined with the interviews cannot totally explain mathematics achievement for the students involved in the study. Instead, these sources of data add to an ever refinable picture of the students ability to perform basic mathematical tasks.

The researcher for this study was unable to find previous reference to the issue of the type of administration for a computer-managed instructional program. Analysis of the data supported the directional hypothesis that favored teacher input to selection of software to be presented to students. This approach allowed the teachers of Group A to customize the instruction to follow activities which occurred in the classroom. Although each member of the class worked on similar courseware, an individualization took place in terms of pace, response, and branching for each topic. The data implies that the process of reinforcing classwork with computer experiences and vice versa was a stronger variable in producing higher achievement scores than diagnosing and addressing individual deficiences.

Access to technology is no guarantee that any students will become more literate. Computers are tools that can provide a medium of instruction, but the tools must be used in practices that are pedagogically sound. The use of computers for instruction in this study appears to have been effective in producing a high level of achievement in mathematics. The software developed by Computer Systems Research Incorporated and used in the study seems to be effective in raising student achievement.

Achievement is affected by the use of a computer-assisted component of instruction and also by the type of software administration utilized in the individual components. The method by which the software is applied in instruction is a decision left to the practitioner. As has been noted the teachers who participated in the study were split over the two types of administration. However, the data supports the common sense approach of allowing the computer-assisted instruction to be determined by the classroom teacher. In this manner the computer activities could parallel and complement other teacher led instructional activities.

Student attitudes toward the use of computers for instruction were reported in a positive light among those students participating in the computer-assisted component of instruction. The feelings of the students and teachers alike favor the use of computers as part of instructional strategies. Educational practices which can infuse enthusiasm into students are highly promoted. A computer enhanced classroom environment offers the potential to generate excitement for learning as well as lessen the burden of the teacher.

Students provided insights and perceptions to the use of computers for instruction via remarks provided during structured interviews. Positive effects were found for attitude toward the use of computers in mathematics instruction. The students felt that the computers were and aid to understanding concepts and learning computational skills. However, anxiety toward learning mathematics was not lessened by using computers. Students still reported difficulty in learning mathematics.

Implications for the Practitioner

Many teachers do not explore the use of computers as part of their instructional strategies. One of the reasons teachers give for not incorporating the use of technologies in teaching practices is unfamiliarity with equipment and software. Training is usually offered on a volunteer basis and follow-up support is not provided. Classroom teachers also complain about the need for release time to preview software programs that might fit the curriculum.

A few hours of training seemed to suffice for successful use of the computer-managed component in the study. The implication is that it is an easy program to implement with existing school staff. The role of the teacher during computer lab sessions is more of a facilitator than an instructor. The teacher has the responsibility to respond to student request for assistance on an individual basis as well as monitor progress and maintain an atmosphere which promotes learning. The teacher should also plan a sequence of activities to ensure a connection to other curricular activities. Teachers should have some training on how to best provide the best possible situation for learning in a computer laboratory environment. The computer has the responsibility of presenting the content of the lesson and activities for the students. The immediate feedback of responses, correct and incorrect alike, is one of the functions that makes computer-assisted attractive and effective.

One area that may not have been fully utilized by the schools is the capabilities of the computer to store student data. The reports (appendices E, F, G) were available for all students involved. The fact that teachers' seldom use of student records may reflect a lack of training and experience in having the information available to them. Theoretically, continuous evaluation on student progress would improve the effectiveness of the program, but was not a factor in the current study.

The restricted sample makes generalizability unfeasible. However, advances in technology and availability of computers are forcing educators to review and revise curricula. Reforms in mathematics instruction are appropriate and necessary. New methods of instruction are inevitable as we teach the children of the twenty-first century.

Data from this study can be included in the accumulation of a persuasive body of evidence that supports the use of computers in the mathematics classroom. This study also adds to the knowledge of use of computer-managed instructional systems and their administration with public school students. It was hypothesized that a close relationship between computer software and classroom instruction would produce higher achievement than allowing software to be assigned without regard to what was going on in the classroom. This was retained and implies that the objectives and timing of software are important factors in their effectiveness.

Recommendations for Continued Research

The current study was conducted in an actual school setting. Research in a realistic environment has advantages over a contrived or simulated approach. The results of the research will mean more to teachers in the classroom if they can see concrete evidence from actual classroom encounters. The findings will be from situations similar to ones teachers face from day to day.

There are many more variables present when attempting to collect data and investigate phenomena under actual classroom conditions. The weakness in such studies is the inability to identify and control all extraneous variables. The researcher tries to establish a situation of similarity such that the major differences found between experimental groups is a result of the independent variable. Guards against threats to internal and external validity can be controlled in the selection of the research design. Examples of attempts to insure validity of findings from the current study include the following: students selected for the study all met requirements for participation in the Chapter 1 mathematics program, each school had five classes participating in the study, testing procedures were standardized and occurred concurrently, each of the teachers followed guidelines for the same curriculum and addressed the same objectives.

More research involving computer-managed instruction is needed. Studies in controlled environments and in existing educational settings are necessary. Studies similar to or replicating the current study will reinforce findings and identify generalizable concepts. Research on the use of computers for delivering instruction is growing. A limited amount has been reported using the current capabilities of computer systems to diagnose defficiences and prescribe remediation activities. Educational research is mandated to the unenviable task of keeping pace with emerging technologies.

Several areas not examined in the current study merit examination. One such area would seem to be investigating what effect would a differentiation of exposure time to the computers would have on achievement. Is twenty minutes three times a week better than fifty minutes twice a week? Is there an optimal range which would produce maximum results? These questions would be important to the educators implementing similar programs.

Another topic of interest would be to analyze data to determine if any differences are indicated between sexes, economic backgrounds, or parent attitudes and home experiences with computers. Finding which students relate to computer instruction would be as beneficial as determining children's learning styles.

One limitation pointed out in the current study was the experience and training of teachers to utilize the wealth of information provided by the computer's management system. It could be hypothesized that the program could be more effective if the teachers would follow student progress more closely through the reports created from the computer's data base.

A longitudinal study that follows students through future studies would help to shed light on questions of retention. Studies involving a full year or multiple years of participation with computer-assisted instruction could provide valuable information for how to implement technology in the schools.

Concluding Statement

There is a future for computers in education. Computer-assisted instruction is not a fad. The power of computers to enhance and initiate learning is tremendous. Many visions and fantasies of educators are a reality or within reach. The questions generated by the current study are numerous.

The evaluation of programs involving computer-assisted instruction is an important endeavor. Careful study and review of current practices are needed to assess appropriateness for an educational setting. Many programs have shown positive effects and are worthy of emulation. Through the evaluation process weaknesses can be revealed and improved upon.

This study examined the effectiveness of a computer-managed instructional system in a middle level remedial mathematics program. It was shown to be effective in improving achievement scores on a posttest instrument. It was also noted that teacher involvement in planning software assignments was more effective than computer diagnosis and prescription.

The use of technology to help present instruction in the schools should not be a haphazard plan. A foundation of research is necessary to guide education's leadership in making intelligent decisions.

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APPENDIX A

LIST OF MATHEMATICS OBJECTIVES

Place Value
- -Write numbers up to millions
- -Compare number values
- -Compare decimal values
- -Write decimals to thousandths
- -Write decimals greater than one to hundredths and thousandths

Addition
- -Adding two 4 digit numbers
- -Adding two 5 digit numbers
- -Estimate sums

Subtraction
- -Subtract two 4 digit numbers
- -Subtract two 5 digit numbers
- -Estimate differences

Multiplication
- -Multiply a 2 or 3 digit number by a 1 digit number
- -Multiply a 3 or 4 digit number by a 2 digit number
- -Estimate products

Division
- -Divide a 3 or 4 digit number by a 1 digit number, zero in quotient
- -Divide a 3 or 4 digit number by a 2 digit number
- -Estimate quotients

Geometry
- -Identify angles
- -Identify parallel lines
- -Identify perpendicular lines

Fractions
- -Write the simplest form of fractions
- -Write fractions or mixed number as a decimal (denominator 10 or 100)
- -Multiply two unit fractions or a fraction and a whole number
- -Multiply a mixed number by a whole number or fraction
- -Add fractions

Decimals
- -Add decimals to thousandths
- -Subtract decimals to thousandths
- -Write a decimal as a fraction
- -Multiply decimal and a whole number

Number Theory
- -Find the least common multiple of two numbers
- -Find the greatest common factor of two numbers

Problem Solving
- -Solve money word problems
- -Solve perimeter and area problems
- -Interpret bar, line, and circle graphs
- -Find average of a group of numbers

APPENDIX B

TOPIC OUTLINES FOR INTERVIEWS

STUDENT INTERVIEWS

- General feelings about school
- General feelings toward mathematics
    - Assessment of difficulty of understanding and learning the subject
    - Assessment of level of enjoyment in working with mathematics
- Reflections on the use of computers
    - Previous experiences
    - Ability to learn mathematics from a computer
    - Assessment of working in a computer lab setting
        - Preference as to the amount of time spent in the lab
        - Amount of distraction in a computer lab
    - Evaluation of the Computer Research System software

TEACHER INTERVIEWS

- General feelings about computers

    Previous experiences

    Attitude toward use with mathematics instruction

    Evaluation of Computer System Research software

    Ability to track individual progress

- Comments on computer lab setting

    Recommendations on scheduling time in the lab

        More or less minutes per session

        Number of days

        Consecutive or alternating days

        Comments on the adjusted role of the teacher in a computer lab

        Ability to supervise class in a lab setting

- Feelings about student achievement via computer instruction

- General Comments, suggestions and recommendations

APPENDIX C

REQUEST TO DO RESEARCH

WINSTON-SALEM/FORSYTH COUNTY SCHOOLS

REQUEST TO DO RESEARCH

I. Name of applicant Michael K. Kestner

Position CAI Specialist Department Curr. & Inst. Date June 2, 1988

II. Title of Project Computer Assisted Instruction Administration

Description of testing or research project: (Please attach a brief description of the project including methods, objectives or goals, survey instruments, etc.)

Using student achievement data to determine the most appropriate administration of a computer-based curriculum

III. Type of facilities desired:

Type of school: Elementary ___ Secondary ___ Middle X [redacted] No of schools 2

Exact dates or periods facilities desired ___ Relative frequency ___

Approx. size of schools ___ Grades ___

Do you desire any specific schools? Name of schools Cook and Kennedy

Reasons: These two schools will have IBM networked labs with Computer Systems Research software and management systems installed.

IV. Involvement of participants:

Number of pupils to be used 4-5 classes Approximate consumption of pupil's time ___ of teacher's time ___ of administrator's time ___.

Number of persons visiting individual schools in connection with project ___.

To what extent will the staff of the school be involved in planning and carrying out the project? This program will be implemented in both schools for the school year 1988-89. No additional time will be needed for teachers. Possibility of a pre and post test will be required of students. Design of the study will be totally undertaken by the applicant with consultation from appropriate coordinat

V. Results:

What will be the value of the results of your research? In General? ___

It is hoped that by trying a variety administration practices, the most efficient and effective means of implementation of computer-based instruction can be determined.

To the school district involved? Winston-Salem/Forsyth County Schools

VI. If you have used public school facilities for research or testing purposes in the past, please list dates and names of schools: ___

VII. Upon completion of the project, the applicant will submit a short memorandum to the participating school district citing any problems or unusual experiences encountered as well as specific comments and observations.

VIII. A copy of the final report will be made available to the participating school district.

The final report is expected to be available on or about January 1989.
(Date)

Michael K Kestner
Signature of Applicant

Address: 1399 Hannaford Rd.
Winston-Salem, N.C.
27103

APPENDIX D

COMPUTER GENERATED STUDENT REPORTS

MULTIPLE STUDENT REPORT

Multiple Student Report for MOS104

Multiple Student Report Page: 1

Course : MOS104 Date: 06-20-1989

ESTIMATING SOLUTIONS TO WORD PROBLEMS USING SUBTRACTION

				... Pretest ...			.. Post Test ..		
Student	#	Comp	Tot Time	Cor	Inc	Score	Cor	Inc	Score
TAJUAN GREEN	070	Y		2	8	20.0	5	5	50.0
		Y	00:43:39	3	7	30.0	9	1	90.0
OSCAR JORDAN	071	Y		2	8	20.0	4	6	40.0
		Y		4	6	40.0	1	9	10.0
		Y	00:00:00	1	9	10.0	2	8	20.0
REGGIE SIMON	072	Y		2	8	20.0	2	8	20.0
		Y	00:00:00	3	7	30.0	0	10	0.0
CHRIS WRIGHT	074	Y		5	5	50.0	5	5	50.0
		Y	01:07:35	5	5	50.0	10	0	100.0
SIRIS WASHINGTON	075	Y	00:19:16	8	2	80.0	0	0	0.0
ANNETTE WHITE	077	Y		3	7	30.0	0	10	0.0
		Y	00:00:00	2	8	20.0	2	8	20.0
LADONNA JORDAN	078	Y		2	8	20.0	2	8	20.0
		Y		4	6	40.0	3	7	30.0
		Y	00:00:00	3	7	30.0	2	8	20.0

MULTIPLE COURSE REPORT

Multiple Course Report for Student 74

Multiple Course Report Page: 1

Student: CHRIS WRIGHT Date: 06-2[illegible]-19[illegible]
Id : PENNS Student #: 074

Course	Pass	Comp Date	Total Time	... Pretest ... Cor	Inc	Score	.. Post Test .. Cor	Inc	Score
SUBTRACTING TWO FOUR-DIGIT NUMBERS WITHOUT REGROUPING									
M0549	1	09-14-88	05:05:18	10	0	100.0	0	0	0.0
SUBTRACTING TWO-DIGIT NUMBERS WITH REGROUPING									
M0547	1	09-14-88	00:09:24	10	0	100.0	0	0	0.0
SUBTRACTING TWO THREE-DIGIT NUMBERS WITH REGROUPING									
M0548	1	09-14-88	00:07:34	10	0	100.0	0	0	0.0
SUBTRACTING TWO FOUR-DIGIT NUMBERS WITH REGROUPING									
M0550	1	09-20-88	05:20:10	9	1	90.0	0	0	0.0
ESTIMATING SOLUTIONS TO WORD PROBLEMS USING SUBTRACTION									
M08104	1		00:00:00	5	5	50.0	5	5	50.0
	2	09-28-88	01:07:35	5	5	50.0	10	0	100.0
ESTIMATING SOLUTIONS TO WORD PROBLEMS USING ADDITION OR SUBTRACTION									
M11105	1	09-28-88	00:20:47	9	1	90.0	0	0	0.0
SOLVING WORD PROBLEMS INVOLVING SUBTRACTION OF THREE-DIGIT NUMBERS									
M05111	1	10-04-88	01:27:48	10	0	100.0	0	0	0.0
SOLVING WORD PROBLEMS INVOLVING ADDITION AND SUBTRACTION									
M08113	1	10-05-88	05:34:27	7	3	70.0	10	0	100.0
READING AND WRITING DECIMALS									
M0810	1	10-11-88	00:05:24	10	0	100.0	0	0	0.0
READING AND WRITING MONEY VALUES									
M0811	1	10-11-88	00:05:30	9	1	90.0	0	0	0.0
ROUNDING DECIMALS BETWEEN ZERO AND TEN									
M0815	1	10-11-88	00:06:20	10	0	100.0	0	0	0.0
ADDING DECIMAL NUMBERS WITH NO MORE THAN TWO DECIMAL PLACES									
M0873	1	10-12-88	00:34:57	7	3	70.0	9	1	90.0
SUBTRACTING DECIMAL NUMBERS WITH NO MORE THAN TWO DECIMAL PLACES									
M0874	1	10-12-88	00:12:34	10	0	100.0	0	0	0.0
SOLVING MONEY PROBLEMS INVOLVING AMOUNTS UP TO FIVE DOLLARS									
M05125	1	10-12-88	00:06:18	10	0	100.0	0	0	0.0

DETAILED COURSE REPORT

Detailed Course Report for Student 74

Course Detail Report   Page : 1

Student: CHRIS WRIGHT   Date : [illegible]
Id : FENN6   Student #: 0?4   Course: MOB104 / ?

ESTIMATING SOLUTIONS TO WORD PROBLEMS USING SUBTRACTION

Label	Ques	Date	Time	Response Code	Inc/Cor	Student Response
01g01	1	09-27-88	11:39:2?	01	INC	c
01g02	1		11:43:30	QC	COR	d
01g03	1		11:44:32	Q1	INC	a
01g04	1		11:45:27	QC	COR	a
01g05	1		11:46:56	QC	COR	a
01g06	1		11:47:52	QC	COR	b
01g07	1		11:49:01	QC	COR	b
01g08	1		11:49:49	Q1	INC	a
01g09	1		11:50:52	Q1	INC	d
01g10	1		11:52:20	Q1	INC	b
02e02	1		11:53:39	QC	COR	d
	2		11:53:44	QC	COR	
	3		11:53:56	QC	COR	u
	4		11:54:00	QC	COR	
	5		11:54:09	QC	COR	u
	6		11:54:21	QC	COR	
02e03	1		11:54:40	QC	COR	b
02e04	1		11:55:12	QC	COR	d
03e01	1		11:55:46	QC	COR	d
	2		11:55:59	QC	COR	
	3		11:56:21	QC	COR	n
	4		11:56:30	QC	COR	
	5		11:56:55	QC	COR	ten
	6		11:56:59	QC	COR	
	7		11:57:07	QC	COR	
	8		11:57:12	QC	COR	
	9		11:57:41	QC	COR	320
	10		11:57:43	QC	COR	
	11		11:57:50	QC	COR	
03e03	1		11:58:10	W3	INC	d
	1		11:58:26	QC	COR	e
	2		11:58:28	QC	COR	
	3		11:59:28	QC	COR	4,739 2,187
	4		11:59:49	QC	COR	
	5		12:00:49	QC	COR	d
	6		12:00:51	QC	COR	
	7		12:01:15	QC	COR	4,700
	8		12:01:18	QC	COR	
	9		12:01:34	QC	COR	2,200
	10		12:01:35	QC	COR	
	11		12:01:58	QU	INC	2.300
	11		12:02:19	QU	INC	2,300
	11		12:03:02	QC	COR	2,500
	12		12:03:04	QC	COR	
04e01	1		12:04:17	QC	COR	b
04e03	1		12:07:03	W2	INC	b
04e02	1	09-27-88	12:07:09	W3	INC	d
	1		12:07:24	QC	COR	c
04e04	1		12:07:?3	QU	INC	
	1		12:08:07	QC	COR	t
05e01	1		12:08:??	SC		[illegible]
	1	09-28-88	11:31:29	QC	COR	a
99g01	1		11:34:10	QC	COR	c
99g02	1		11:35:02	QC	COR	a
99g03	1		11:36:18	QC	COR	d
99g04	1		11:37:41	QC	COR	b
99g05	1		11:38:49	QC	COR	o
99g06	1		11:4?:54	QC	COR	c
99g07	1		11:43:26	QC	COR	a
99g08	1		11:45:18	QC	COR	b
99g09	1		11:46:10	QC	COR	b
99g10	1		11:47:25	QC	COR	d
99w00	0		11:48:55	CC		

APPENDIX E

SAMPLE PRETEST AND POSTTEST PROBLEMS

What is 204,120 in written form?

a) twenty four thousand, one hundred twenty eight
b) two hundred four thousand, one hundred twenty eight
c) two hundred forty thousand, one hundred twenty eight
d) two hundred forty one thousand, twenty eight

56,093 is less than

a) 56,099
b) 56,003
c) 56,053
d) 56,009

Add: 43,678
+ 21,456

a) 64,034
b) 64,134
c) 64,024
d) 65,134

Subtract: 17,034
− 5,982

a) 10,158
b) 10,156
c) 12,336
d) 11,052

Multiply: 125
× 5

a) 525
b) 515
c) 625
d) 505

Which of the following sets of lines represents a pair of parallel lines?

a) 

b) 

c) 

d) 

The least common multiple of 3 and 6 is

a) 3
b) 9
c) 12
d) 6

What is the simplest form of $\frac{48}{56}$?

a) $\frac{24}{28}$
b) $\frac{6}{7}$
c) $\frac{12}{14}$
d) $\frac{6}{14}$

Multiply: $\frac{3}{5} \times 10$

a) $16\frac{2}{3}$
b) $\frac{1}{6}$
c) 6
d) $10\frac{3}{5}$

The greatest common factor of 10 and 15 is

a) 5
b) 2
c) 3
d) 25

Estimate the sum:

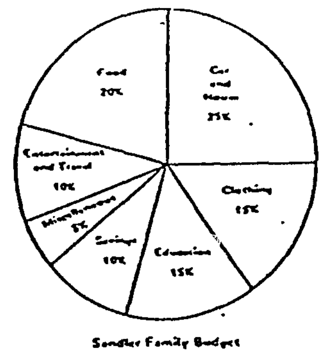
673 + 328 =

a) 300
b) 900
c) 1,100
d) 1,000

Divide: 78)4,368

a) 56
b) 61 R10
c) 51 R38
d) 66

What percent of the Sandlers' budget is spent on food and clothing?



a) 15%
b) 20%
c) 35%
d) 25%

Twelve people equally shared a large pizza cut into 24 pieces. How many pieces did each person eat?

a) 12
b) 2
c) 4
d) 3

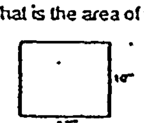
Which unit of measurement should be used to measure the Eastern Coast of the United States?

a) centimeters
b) millimeters
c) meters
d) kilometers

Kim's telephone bill is $14.83. If she has 2 five-dollar bills, how much more does she need to pay the bill?

a) $5.23
b) $9.83
c) $5.17
d) $4.83

What is the area of this rectangle?



$A = l \times w$

a) 60 sq. in.
b) 120 sq. in.
c) 22 sq. in.
d) 484 sq. in.