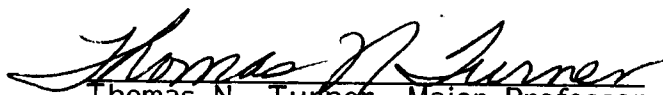


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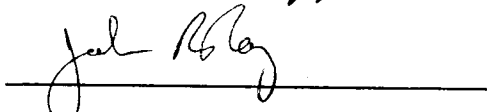
I am submitting herewith a dissertation written by Diane Lind Darling entitled "A Study of the Effects Using Microcomputers on Achievement in Mathematics Basic Skills." I have examined the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Education, with a major in Curriculum and Instruction.

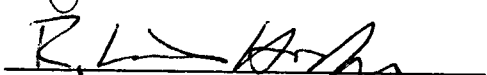

Thomas N. Turner, Major Professor

We have read this dissertation
and recommend its acceptance:









Accepted for the Council:



Vice Provost
and Dean of The Graduate School

A STUDY OF THE EFFECTS USING MICROCOMPUTERS
ON ACHIEVEMENT IN MATHEMATICS
BASIC SKILLS

A Dissertation
Presented for the
Doctor of Education
Degree
The University of Tennessee, Knoxville

Diane Lind Darling

March 1986

DEDICATED

To my Aunt Velma Moore,
an educator for many years,
who taught me to read.

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ABSTRACT

The study was initiated for the purpose of ascertaining whether an approach which involved the use of a microcomputer was superior to an approach which did not include the use of the microcomputer for helping low achievers learn some basic mathematics skills. The subjects consisted of 36 low achievers from six Knoxville City schools. All students received mathematics instruction from their regular classroom teachers. Students in the experimental group received drill and practice on the microcomputer for 1½ hours each week during the period of the 12 week study. Students in the control group received drill and practice activities without the use of a microcomputer during the same time period. Subjects in both groups were given a pretest on the Knoxville City Mathematics Basic Skills Test at the beginning of the school year. At the end of the 12 weeks subjects were given a posttest. The Knoxville City Mathematics Basic Skills Test was used for both the pretest and posttest. The data were treated using an analysis of covariance. On the 10 skills for which computer treatment was given the experimental group scored significantly higher than the control group in one skill, slightly higher in 6 skills, and slightly lower in 3 skills. In conclusion computer drill and practice seems to be as effective as traditional drill and practice activities.

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CHAPTER 1

INTRODUCTION

In 1982, the Knoxville City School System adopted a promotion-retention policy requiring 70% mastery of identified basic skills in mathematics and reading in order for a student to move on to the next grade level. Mastery entailed correctly answering specific questions and solving specific problems on a paper and pencil test. A major concern for teachers at every grade level is to develop strategies to help all students in the class achieve mastery regardless of their previous acquisition of skills. A teacher who has within the classroom children at different levels of progression has the task of meeting each child's individual needs. Because a teacher's time is limited, tutoring every child within a specific skill area may be a very difficult--if not impossible--task. Children are generally placed in groups according to their skills. However, there are normally a few students who are extremely low achievers and need special attention. Sometimes these students may be unduly challenging to a teacher who wants to move the class ahead but must spend a large portion of the time tutoring. One possible alternative to this problem is the use of a microcomputer.

The microcomputer as a machine is unlike any human in one respect. It never tires of repeating the same information over and over. This repetition is valuable to the low achiever but is often seen as boring to the teacher and students who are ready to move on to other skills. At the time of this study, the microcomputer was

relatively new to the elementary school, and not much research had been conducted concerning its use in mathematical instruction. However, there is a considerable amount of research concerning computer-assisted instruction, usually on a time shared computer system such as PLATO or TICCIT. Jamison, Suppes, and Wells (1974) noted that,

When small amounts of CAI are used as a supplement to regular classroom instruction (as with the elementary school drill-and-practice programs), substantial evidence suggests that it leads to an improvement in achievement, particularly for slower students. (p. 56)

Research was needed to ascertain whether the microcomputer could produce similar improvement in mathematics achievement.

As a further advantage indicated by research, computer-based education was reported to "reduce learning time 40% to 50% with equal or increased retention when compared with traditional learning" (Hall, 1982, p. 362). If the microcomputer can, in fact, tutor a child on his/her level and utilize less time than traditional teaching, the microcomputer could be a possible solution for aiding students who are behind grade level in acquiring their basic skills.

Purpose

The purpose of this study was to ascertain whether an approach which involved the use of the microcomputer could aid low achievers in developing their basic mathematics skills better than by using an approach without the microcomputer. The Knoxville city school's basic skills objectives and tests were utilized as the criteria for measuring success in acquiring the basic mathematics skills. The major research

question for this study was whether drill and practice on the micro-computer would yield any significant gains in acquiring basic mathematics skills when compared with traditional drill and practice.

Hypothesis

The data derived from this study were used to test the following null hypothesis:

✓ There will be no significant difference in the scores on the Knoxville City Schools first semester mathematics basic skills test for students who receive drill and practice on the microcomputer when compared to scores of students who received traditional drill and practice without the use of a microcomputer.

Need for the Study

During the early 1980s, education began to enter an era of computer mania. Many of the educational journals covered their pages with articles such as "It's 1980: Do You Know Where Your Computer Is?" (Seidel, 1980, p. 481). Computer literacy became a major educational emphasis in the State of Tennessee. In fact, next to the State's emphasis on the "Basic Skills First" movement, computers ranked top priority. Therefore, many educators began to be concerned about acquiring computers and computer software for their school systems. Many of these educators felt the urgency of the computer trend and jumped on the computer bandwagon without appropriate regard for the future use of computers. Computer literacy is a positive goal, but

why stop there? What about the future use of this equipment? The future could hold numerous possibilities such as computer-assisted instruction, computer tutoring, and computer- managed instruction, to list a few. If equipment is to be purchased with the idea of making students computer literate, why not consider all the possibilities of such equipment?

Much of the research on computers and computer-assisted instruction has been conducted on large computers that involve timesharing (PLATO, TICCIT). Educators need the results of similar studies involving microcomputers to ascertain all the capabilities such machines can contribute to the field of education.

At the time of this study, there was a limited amount of research on the use of the microcomputer as an aid to teachers in instruction. Without research supporting the advantages of such equipment, extensive purchase of modern computers and software is questionable. In the State of Tennessee, emphasis was on basic skills first. Computer literacy itself was treated as less essential. Therefore, evidence as to whether the microcomputer does, in fact, aid in teaching the basic skills would certainly help educators acquire computer equipment for their schools. Ultimately a study of the effectiveness of microcomputers in helping students gain basic skills becomes not only justifiable but necessary in order to ascertain if the microcomputer will, in fact, be a useful tool. Such a study should provide valuable data for educators who may be considering the purchase of microcomputers and should be conducted while public interest in the computer remains high.

Definition of Terms

Terms with specific meanings for this study include the following:

Basic mathematics skill. A mathematics skill required by the Knoxville city schools as basic for a particular grade level (fourth grade has a list of 23 basic mathematics skills for the first semester).

Basic skills test. A criterion referenced test designed by the Knoxville City School System to test a list of 23 identified skills designated by the Knoxville City System as basic mathematics skills. This list is not inclusive of all skills considered to be basic but represents only those skills tested on the fourth grade first semester mathematics posttest.

Computer-assisted instruction. Computer-assisted instruction (CAI) given via computer can be exhibited in four common modes: drill and practice, simulation, tutorial, and games.

Computer-based instruction. Computer-based instruction for this study is synonymous with CAI.

Computer-managed instruction. A program designed to keep records of a large number of students, give students the appropriate level of instruction or assignment, and record student's test scores. The computer in this sense primarily aids the teacher in managing the instruction.

Computer literacy. This includes an introduction to the history of computers, the uses of computers in our society, safety factors of the computer, and a minimal amount of computer programming usually

in the basic language. Computer literacy does not require the use of CAI.

Control group. Those fourth grade low achievers who received conventional instruction in mathematics basic skills as required by the Knoxville city schools. Practice or drill sessions used conventional materials and approaches but made no use of microcomputers.

Conventional drill and practice. Conventional means any drill and practice which does not include the use of the microcomputer. According to the mathematics supervisor, textbook drill activities are often used, but initial instruction should include the use of manipulatives. Other drill activities might include peer tutoring with flash cards, learning centers, and mathematics games. However, these activities would occur less often than the textbook drill activities and worksheets.

Experimental group. Those fourth grade low achievers who received conventional instruction in mathematics basic skills as required by the Knoxville city schools. Practice or drill sessions used the microcomputer in place of more conventional drill approaches.

Low achievers. Students who scored at the lowest 10% of the fourth grade students in their school on the mathematics basic skills pretest designed and given by the Knoxville city schools. These low achievers did not represent students who were certified learning disabled and therefore already receiving additional attention in a resource class.

Mastery of the basic skills test. Mastery was attained when a child mastered 70% of the mathematics skills given on the posttest.

Mastery of a skill. The mathematics basic skills test required by the Knoxville city schools had four problems for each skill tested. Mastery was attained when a student answered three of the four problems correctly.

MECC. The Minnesota Education Computing Consortium formed in 1972-73 to coordinate computer use in all levels of education and in the State of Minnesota. MECC completed over 150 Apple II computer programs which were available to computer users for a modest charge (Hall, 1982, p. 361).

Microcomputer. A desk top computer which generally cost less than \$2,000 and was marketed as a microcomputer or personal computer. In this study just one type of microcomputer was utilized, the Apple IIe.

Pretest. In this study the pretest refers to the mathematics basic skills test given in the fall by the Knoxville city schools. The same test was given in January as the posttest.

Posttest. In this study the posttest refers to the mathematics basic skills test given in January by the Knoxville city schools. (An alternate form of the test was not available at the time of the study.) The posttest and pretest were the same test.

Assumptions

For this study a number of assumptions were considered necessary:

1. Low achievers would benefit from repetition through drill and practice.
2. Computer software utilizing drill and practice directed toward specific mathematics skills offers sufficient variety and repetition to provide the maximum benefits of a CAI program.
3. A minimum amount of instruction will enable students to operate microcomputers efficiently enough to maximize benefit from CAI instruction on specific mathematics skills.
4. All students in the experimental group have had equivalent previous experience with microcomputers.
5. Microcomputers will be increasingly available in schools for student use.
6. Students in the control and experimental groups were similar in family and socioeconomic backgrounds.
7. Students did not experience mathematics drill and practice with microcomputers outside of school.
8. Teacher treatment in the study was considered similar among all teachers of both groups since all were aware of the Knoxville City mathematics pretest scores, had the same textbook materials, similar supplementary materials, and were required to spend the same amount of time for mathematics instruction.
9. Field based research is valuable research even though significant variables can not be controlled as they can in laboratory research.

Limitations of the Study

Certain limitations of this study need to be considered including the following:

1. A major limitation of this study related to the test that was used. This test had been required by the Knoxville city schools to assess mastery of the fourth grade basic mathematics skills. This test included four questions for each skill taught at the fourth grade level in the Knoxville city schools. One problem was that no published statistical reliability or validity measure has been established by this test. A second problem of concern was that these skills were tested by such a small number of test items.

The Knoxville city schools' mathematics basic skills test was used for a number of reasons. First, the test was specifically designed to measure students' mastery on the mathematics basic skills taught in the Knoxville city schools. Second, it was already an established test used by all students within that system. Finally, the students were required to master 70% of the skills tested for promotion to the next grade level.

2. Schools selected for use in this study might not have been typical of other Knoxville city schools and certain other elementary schools in the United States.

3. The available software used in the study did not present all the necessary skills. Therefore, skills not included in the software were not reinforced for the experimental group by drill and practice on the computer.

4. The researcher could not monitor students' time or be totally assured that students worked with appropriate software during their practice and drill exercises. While the researcher made the assumption that individual teachers would be constant in their monitoring and scheduling, it is likely that each teacher monitored and scheduled in different ways.

5. Resources and activities utilized in the conventional practice exercises may have varied considerably among the subjects. Therefore, the term conventional may not represent a composite approach.

Methods and Materials

At the time of this research, the Knoxville city schools had at least 10 elementary schools with one or more microcomputers. The city school system also had access to mathematic software developed for the Apple computer by MECC. A study to ascertain whether a microcomputer has any effect on raising mathematics scores on the city's basic skills test would help administrators, teachers, and parents in the future use of microcomputers. The specific purpose of this study was to ascertain whether an approach which utilized the microcomputer did, in fact, promote mathematic achievement in mathematics basic skills better than an approach which used only conventional drill and practice.

This study involved low mathematics achievers in the Knoxville city schools. Selection was based on performance on the mathematics basic skills test given by the Knoxville city schools. Low achievers

were identified as those who scored in the lowest 10% of their class on the pretest of mathematics basic skills designed by city educators for use in the city schools. Children identified for the special education program or for resource classes were not included. All of the low achievers included in the study were given $1\frac{1}{2}$ hours a week of drill and practice type activities. The study took place during a three month period in the 1983-84 school year.

Students in schools where computers were not available were chosen for the control group. They were selected from schools of the same socioeconomic level and from classrooms with similar enrollment as those of the experimental group. Control group schools also had similar community interests. Students in the control group spent equivalent time with drill and practice activities to that of the experimental group. However, students in the control group were given mathematics drill utilizing paper and pencil activities from the Heath fourth grade textbook. A correlation of the Knoxville city schools first semester basic skills and the corresponding textbook activities is presented in Chapter 3. These students also received worksheet activities from Heath Basic and Enrichment workbooks. Individual teachers made some materials such as bulletin boards and interest centers to further facilitate learning of the Knoxville City mathematics basic skills.

The experimental group constituted those students in schools with Apple IIe computers available to them for their use. Students in the experimental group received the appropriate drill and practice working

at a microcomputer. These students used the MECC mathematics programs available to the Knoxville city schools for elementary students. There were four diskettes for skills taught at the elementary level. The classroom teacher chose from among the four the one appropriate for the child's individual needs. Since many schools had received "Elementary My Dear Apple" (a promotional diskette given with the purchase of an Apple IIe), the supermath program on that diskette was also used.

Since mastery of basic mathematics skills had been mandatory only in grades 1 through 3 at the close of the previous school year, the grade level involved in the study was the fourth grade. Students in the fourth grade had been required to master, during the previous year, third grade mathematics basic skills in order to be promoted. These students had been in the system long enough to have learned school rules and study habits. Fourth grade students also required less monitoring than younger children because their attention spans were longer. The available software was also more compatible with upper elementary mathematics skills than introductory ones.

The elementary schools involved were those in the Knoxville City School System where a microcomputer was available and in which personnel agreed to monitor the time the fourth grade students spent utilizing the drill and practice offered. Schools that did not have computers, but who did have the same socioeconomic level, student enrollment, and community interests, were selected on the basis of similarity to the schools using the computers. The number of students

involved depended upon the enrollment of each school's fourth grade class. If there were 50 students in a school's fourth grade, then that would involve 5 students who had the lowest scores on the mathematics pretest.

Organization of the Study

The study has been reported in five chapters and an appendix. Chapter 1 introduces the study, providing background, need for the study, purpose statement, and procedures. The basic assumptions and limitations of the study are also explained in Chapter 1.

Chapter 2 reviews the literature of the microcomputer and computer-assisted instruction as related to public school elementary mathematics education.

Chapter 3 explains the procedures used in giving students drill and practice on the computer. The chapter additionally explains the computer programs and how the computer time was provided for each student.

Chapter 4 presents and analyzes the data in relation to the student's test performance. Comparisons of test scores between students who utilized computer drill and practice and those who did not were reported. An analysis of covariance between groups was reported for each skill tested.

Chapter 5 offers summary and a discussion of findings regarding the value of the microcomputer and its use in mathematical instruction. Chapter 5 includes recommendations for future use of the microcomputer within the Knoxville City School System.

CHAPTER 2

LITERATURE SURVEY

The purpose of this study was to ascertain whether the use of a microcomputer could aid low achievers in developing their basic mathematics skills better than a traditional approach alone. The Knoxville city schools' basic skills objectives and tests were utilized as the criteria for measuring success in acquiring the basic mathematics skills. The major research question for this study was whether drill and practice on the microcomputer would yield any significant gains in acquiring basic mathematics skills when compared with traditional drill and practice.

The review of the related literature included the literature on the history of the computer, development of computer-assisted instruction in education, the changes resulting from the use of computer-assisted instruction, and more specifically the use of the microcomputer as it related to mathematic instruction. The review did not include literature dealing with computer literacy or the use of computer programming in education. Both were worthwhile subjects but were only peripherally related to this particular study. This review was restricted to that body of literature related to computers and the enhancement of mathematic achievement.

History of the Computer

The first multipurpose electronic computer was built at the University of Pennsylvania in 1946. Prior to this time only calculating

devices or machines of single purpose were in operation. The first electronic computer called the ENIAC filled a large room, weighed 30 tons and used vacuum tubes. The ENIAC (Electronic, Numerical, Integrator and Calculator) would only run 7 or 8 minutes before a tube failure would occur. It also had little memory when compared to the computers of the 1980s. The cost of this computer was more than half a million dollars. By 1984 a computer with the same amount of computing power would cost around \$1,000 and could be placed on a desk. Much has been learned since 1946 (Moody, 1978, p. 3; Namkung, 1975, p. 9).

The first computer constructed for business rather than for scientific applications was the UNIVAC. The UNIVAC came on the market in 1951. The Census Bureau and General Electric were the first consumers of the computer market. The Census Bureau acquired the UNIVAC to process the huge amount of data acquired in the 1950 census. The General Electric Company purchased the computer for both processing business data and for business application of the computer (Lynch & Rice, 1977, pp. 40, 45).

The use of transistors to replace the vacuum tubes was the first major improvement in computers. With this technological advance computers became smaller, less expensive, faster, and more reliable. The introduction of the transistorized computer marked the Second Generation in the computer age. The first of these, the IBM 7090, was delivered late in 1959 and several other computers from various companies followed shortly thereafter (Lynch & Rice, 1977, p. 43).

The integrated circuit marked the beginning of the microcomputer era and was often referred to as the Third Generation in the computer age. The creation of the integrated circuit began with Hoff and a team of scientists at Intel of California who succeeded in building an arithmetic/logic unit on a single integrated circuit chip. This first integrated circuit was developed in 1969. By 1971 a central processing unit was created on a single chip. The first microprocessor called the Intel 4004, was smaller than 1/6 by 1/8 inches and consisted of 2,250 transistors. This tiny chip was almost equal in computer power to the earlier ENIAC. In just 20 years the computer was reduced from the size of large room to a microprocessor less than 1 square inch in area. These improvements made it difficult for the application and programming of the computer to keep pace with the changes made in the structure of the computer (Baker, 1982, pp. 17, 18).

What cost half a million dollars in 1950 could by 1984 be purchased at a fraction of that cost and housed within a fraction of the space previously required. It was not surprising that as the price and size were reduced the applications and uses for the computer were increased. What was created in 1950 for scientific applications could in the 1980s be marketed for personal use with multiple applications (Baker, 1982, p. 18).

Developments of CAI in Education

During the late 1950s and early 1960s preliminary experiments in computer-assisted instruction began in the United States. The funding for these experiments came from private foundations, major computer

vendors, or federal agencies such as the National Science Foundation. The projects were conducted in several major universities, among which were Dartmouth, Stanford, and the University of Illinois. During this period many educators had high expectations of CAI and predicted that CAI would change the entire structure of education (Chambers & Sprecher, 1983, p. 6).

The Project at Dartmouth

In June 1967 the National Science Foundation aided Dartmouth College in a 3-year project to explore the use of computing in secondary schools. Eighteen schools participated in the project. Some of the schools were private and some were public schools. The schools involved were scattered over five New England states. Both classroom and extracurricular uses of computing were explored by students and teachers (Kurtz, 1970, p. 5).

The Dartmouth project developed a simplified way to program a computer. This new way of programming became known as BASIC. The language was used to develop many CAI programs for use in the public schools (Chambers & Sprecher, 1983, p. 6).

One of the primary goals of the Dartmouth project was for teachers to be able to prepare their own written curricular materials called "topic outlines" for use in teaching students problem solving on the computer. The final report of the Dartmouth project indicated that over 40 outlines or lessons had been produced. As part of this computer program teachers, with some support from the central institution, were able to develop parts of courses and prepare their own

material for use on the computer. These computer lessons had been used in conjunction with the regular classroom assignments but were not used as total courses in any subject. According to Kurtz (1970, pp. 2, 21), many students and teachers benefitted from the study. One of the results was a new way to identify problem solving. Students were then given the responsibility of teaching various tasks to the computer.

The Project at Stanford

Suppes (Suppes & Morningstar, 1969, pp. 343-345) developed one of the earliest drill-and-practice programs in elementary mathematics. The main purpose of the program was to provide drill and practice in arithmetic skills as a supplement to regular classroom instruction. The Stanford Achievement Test, used as the primary source of evaluation, was administered to both experimental and control classes. Suppes found results indicated significant increases in the performance level of those students using the computer. The one exception occurred when a control school added 25 extra minutes of classroom drill and practice to their curriculum. This school performed significantly better than the experimental school which received only 5 to 8 minutes of computer drill.

Suppes continued to conduct research projects, including the Chicago City Schools Project. This project provided tutorial lessons in mathematics and reading. It was designed to improve skills in these disciplines and has had significant results. Studies in CAI materials

for the gifted, courses in Russian, philosophy, mathematics and music have also been a part of Suppes work (Chambers & Sprecher, 1983, p. 7).

The Project at the University of Illinois

In 1960 research began at the Coordinated Science Laboratory of the University of Illinois. The purpose of this research was to explore the possibilities of computers in individual instruction. The result of the research led to a teaching system called PLATO (Programmed Logic for Automatic Teaching Operations). Donald Bitzer directed the project with support from Control Data Corporation and the National Science Foundation (Lyman, 1981, p. 5).

In January 1967 the Computer-based Education Research Laboratory (CERL) was organized to continue the research and operation of the PLATO system. The authoring language developed for use in PLATO was called TUTOR. The TUTOR language allowed time-sharing of the system by students and authors simultaneously. The PLATO lessons have advanced from PLATO I to PLATO UI. In 1981 the PLATO UI system supported approximately 1300 terminals in over 200 locations. Among these were Minneapolis, Minnesota; Tallahassee, Florida; Newark, Delaware; Sunnyvale, California; Toronto and Edmonton, Canada; and Belgium (Lyman, 1981, p. 7).

One of the interesting developments of the PLATO system was its use of computer terminals that allowed students to respond by touching the correct spot on the screen. These computer terminals utilized

plasma display panels which permitted instant response from television-type screens connected to a main computer. Graphics and animation capabilities were also available on these terminals as well as the touch control system (Chambers & Sprecher, 1983, p. 8).

The PLATO materials were used and evaluated in five community colleges. The results of this research indicated that a large number of students developed positive attitudes toward Plato-type materials. Positive achievement effects were also reported in the academic area of mathematics. No significant achievement effects were found for any other subjects either in favor of PLATO of the traditional classroom (Chambers & Sprecher, 1983, p. 9).

The Control Data Corporation acquired the rights to the PLATO system and marketed CDC PLATO all over the world. By the time of this study, CDC PLATO was available for microcomputers. However, some of these programs were used in conjunction with a minicomputer or a mainframe computer. Because many of the programs available required the use of a minicomputer or mainframe computer, school districts without access to the larger computers were not able to take advantage of these materials.

Although this early research has not changed the entire structure of education, it has provided valuable data for the classroom. The research done at Dartmouth, Stanford, and the University of Illinois all indicated positive results in the area of mathematics. More research will be needed as computer technology and the programs are improved.

Later CAI Developments

The TICCIT (Time-shared Interactive Computer Controlled Information Television system) project was funded in 1971 by the National Science Foundation (a joint project between the MITRE corporation and the University of Texas). A main goal of the project was to develop market success by providing a low cost, high quality program. Mitre sought to avoid school resistance to CAI and chose the community college as an appropriate test case for market success (Alderman, 1978, p. 35).

Findings of the TICCIT program supported the potential of CAI as an effective resource. The students who received TICCIT classes acquired higher posttest scores than similar students in traditional classes. A 10% gain in achievement was reported for students in TICCIT mathematics courses and a 5% gain in English courses (Alderman, 1978, p. 27).

The TICCIT courses were developed using minicomputers, color TV, and graphics. The development of the TICCIT courses also utilized the expertise of psychologists and content specialists (Chambers & Sprecher, 1983, p. 11). The computer could no longer be considered as the answer to all educational problems. It could be utilized as a tool but, as such, must follow other educational considerations. Instructional design, manner of implementation, nature of the student, and role of the teacher should all be considered. Despite the success of the TICCIT project in achievement there were dramatic decreases in course completion rates. Students who were unable to manage their

own learning failed to satisfy course requirements. If the majority of students are not able to manage their own learning the TICCIT program would not be beneficial (Alderman, 1978, pp. 27, 28).

Philadelphia city schools under the direction of Charp (1981, p. 21) also used computers to improve basic skills. Computers were used to individualize instruction for low income inner-city children. Many of these children attended class sporadically and were not able to keep pace with other students. These students usually had a disproportionate rate of academic failure and often dropped out of school. Through the use of individualized computer lessons students began at the level of their understanding and proceeded to catch up. Material that was not mastered could be presented again in a different variation. This use of individualized computer lessons would permit students to work at their own pace without the stigma of being placed in a lower grade level. The success of these disadvantaged students was reported as either the same or greater than those children taught in the regular classroom.

Changes Resulting from CAI

Improvements in Learning

Educators are most often interested in results and more specifically achievement gains. In the years just prior to this study there began an increased emphasis in basic skills. It was not surprising that educators did not want to utilize new materials unless they could produce positive results in improving achievement in basic skill areas.

The available research indicates that CAI did as well or better than traditional classroom methods in improving achievement in mathematics skills (Burns & Bozeman, 1981; Davis, 1980; Delforge & Blosser, 1976, 1977; Dorsey & Burleson, 1982; Jamison et al., 1974; Kulik & Bangert-Drowns, 1984; Lysiak & Wallace, 1975, 1976; Palmer, 1973; Ragosta, 1983; Suppes & Morningstar, 1969).

Reduction in Learning Time

Research has consistently shown that CAI reduced learning time when compared with traditional instruction. One review reported learning time could be reduced as much as 40-50% (Hall, 1982, p. 363). Kulik, Kulik, and Cohen (1980) found a significant difference in instruction time required by conventional classes and those of CAI classes. The conventional classes required about 1.25 more hours of instructional time than did the CAI classes. Research consistently reported a reduction of learning time, although the amount of reduction varied between studies (Burns & Bozeman, 1981; Chambers & Sprecher, 1983; Hall, 1982, p. 363; Kulik et al., 1980, p. 537; Kulik et al., 1984, p. 150; Levin, 1972).

Positive Student Attitudes

The computer has been shown to provide immediate feedback to the learner and to individualize the pace of instruction. Because of these and other facts, research has found student attitudes to be consistently favorable to CAI (Bohrer, 1981; Copple, 1981; Kulik et al., 1980; Magidson, 1978).

CAI Research on a Microcomputer

The researcher was unable to identify research projects on a microcomputer utilizing CAI to the extent of PLATO or TICCIT. One reason for this might be a reduction of funding. According to Bork (1982), "no significant sizable amounts of curriculum development in the sciences have been sponsored by the National Science Foundation since about 1972" (p. 25). An article by Suppes and Macken (1978) also reported, "There is currently a severe restriction of research funds compared to even quite recent years" (p. 25). It is possible that the lack of funding created a gap between the potential to do research created by the emerging computer technology and the number and size of research projects.

One study related to mathematics basic skills and the microcomputer was conducted by Henderson (1983). In this study 11 volunteers in a remedial mathematics program participated in CAI modules presented on an Apple II+ microcomputer. These CAI modules covered factors and prime numbers for fractions. The students were given a pretest and a posttest. The results were statistically analyzed by an analysis of variance. The results indicated that the lessons presented through CAI on a microcomputer were effective in teaching secondary mathematic students.

Several research projects were conducted about the same time as this study. The lack of literature for research on the microcomputer was mentioned in many of them (Campbell, Norm, Leigh, & Peck, 1985, p. 2; Suydam, 1985, p. 35; Trifiletti, Frith, & Armstrong, 1984,

p. 69). From the literature there appeared to be a lack of evidence to support or dismiss the use of a microcomputer as an effective method of instruction.

Existing research on the use of a microcomputer to improve mathematic achievement in the elementary school has only partially supported the use of microcomputers as a method of instruction. Some studies supported the use of the microcomputer while others supported the use of paper and pencil drill as a superior method. The research was reviewed as a basis for understanding the study.

Swadner (1984) investigated the use of personal computers and cross aged instruction. In this study 34 high school students and 34 6th-grade students were involved with the microcomputer. The high school students received training on the microcomputer to be tutors using the microcomputer to low-achieving 6th-grade students in mathematics. The 6th-grade students were tutored for 18 weeks. The high school students had received 18 weeks of training before the tutoring period. Students were given a pre- and posttest treatment for mathematic achievement. There was no significant improvement on the mathematic achievement as a result of the study. Attitude differences were also reported by Swadner. The 6th-grade students had positive attitudes towards the computer, science and technology, and mathematics, but were not influenced by the tutoring. The attitudes of the high school students became significantly more positive because of the study.

Leigh, Horn, and Campbell (1984) conducted a study comparing the performance of third grade students on division of whole numbers

using a microcomputer. The subjects were 48 students from three third grade classes. A matched pair design was utilized to place half of the students using the computers and half the students receiving paper drill. The results of the study showed no significant differences after a 5-week period. Student progress toward mastery of 90% on a 50-item test favored the print group. Twenty students in the print group compared with 18 students in the computer group mastered 90% on a 50-item test. However, the difference in performance between the two groups was not statistically significant.

In a study conducted by Lanese (1983) in the Cleveland Public Schools, microcomputers were used to provide supplemental remedial instruction in mathematics for students in grades 7-12. The study cited operational problems and admitted that students received limited delivery of service. Twenty public schools and 1,200 students were involved in the study. Each school had only two microcomputers. The objective to raise mathematics computational skills in 75% of the students served was not met. Half the students in grades 7, 8, and 11 raised mathematics skills by 10% measured by percentage of pretest and posttest gain.

A study using Apple II computers was conducted by Ignatz (1982) with the general mathematic students at the Florida A&M University Laboratory School. The purpose of the project was to design materials to help students in grades 6-12 with word problems in everyday mathematics. The project materials were field tested and the results indicated that microcomputers were effective tutors. The students

enjoyed learning with the project materials. The majority of the students increased their problem solving skills. The overall mean increase was 32% as measured by the evaluation test.

A study conducted by Trifiletti et al. (1984) utilized the micro-computer in place of a resource room to teach mathematics skills to learning disabled students. The subjects were 28 students from a private school in Florida. The students were randomly assigned into two groups. One group received 40 minutes per day of computerized instruction in mathematics (Spark-80 courseware) and the other group received 40 minutes of instruction from their teacher. The analysis of achievement gains as measured by the Key Math Diagnostic Arithmetic Test revealed a significant increase in achievement for the group using computers.

The last study involved fourth grade students and computer assisted instruction as a supplement to their classroom instruction (Carrier, Post, & Heck, 1985). The subjects were 144 students from six fourth grade classrooms. Students were ranked on the basis of their mathematics scores on the Iowa Tests of Basic Skills and a matched design was used to determine the groups. One group received instruction on the microcomputer and the other received similar drill on worksheets. The results were determined by a univariate analysis of covariance for multiplication and division facts. A multivariate analysis of covariance was also performed for each of the topics. The results showed that computer programs led to higher achievement and retention of basic multiplication facts. The researchers found no difference for retention and achievement of symbolic

algorithms in multiplication and division. The analysis showed higher achievement in division facts for the computer group but no greater retention than the other group.

The use of microcomputers to aid low achievers in developing basic mathematics skills better than by using a traditional approach was not substantiated from a search of the literature cited above. Neither could definite conclusions be drawn from the rest of the research. Some studies indicated significant achievement gains while others did not. It might be speculated that the courseware used on the microcomputer could make a difference in the achievement gains. The literature also suggested a lack of quality courseware for the microcomputer (Gerling, 1984, p. 22; Williams, 1984, p. 41).

Summary

A review of the literature on the history of the computer, the development of computer assisted instruction in education, and research on the use of computer assisted instruction with microcomputers has established the growing use of computers as a teaching tool. The improvements made on the computer over the past 30 years have reduced both its cost and size. Computers have become much more affordable and easier to use and store. The research on computer assisted instruction in the field of education has consistently shown that computers required less learning time for students, and has produced greater achievement gains than more traditional instruction. The research also indicates that students hold favorable

attitudes towards computer assisted instruction. The research on the microcomputer has shown mixed success for its use in developing mathematics achievement. Some studies report significant gains for the microcomputer and others do not. There is a limited quantity and quality of research available on the microcomputer. More research is necessary to ascertain the possible benefits of the use of the microcomputer in the elementary classroom.

CHAPTER 3

INITIAL PROCEDURES

Introduction

The purpose of this study was to ascertain whether practice and drill with the use of a microcomputer could aid low achievers in developing their basic mathematics skills better than with a conventional approach. The review of the literature indicated that the use of a computer aided the student in three ways. First, the computer aided the student in gaining achievement (Burns & Bozeman, 1981; Kulik et al., 1980; Suppes & Morningstar, 1969). The computer saved the student learning time (Burns & Bozeman, 1981; Kulik et al., 1980, 1984). Research indicated that "computer-based learning can reduce learning time 40-50 percent" (Hall, 1982, p. 363). Lastly, the student developed a positive attitude toward the computer and often towards the subject studied on the computer (Kulik et al., 1980).

Permission was granted by the Research and Public Relations Office of the Knoxville City School System to conduct a study on the microcomputer and mathematics basic skills in the Knoxville city schools. At the time of this study, the Knoxville City School System required students in grades 1-3 to pass a mathematics basic skills test designed by the System in order to be promoted to the next grade. This test consisted of four examples for each of the skills which had been designated as basic for that particular grade level. Students enrolled in the Knoxville City School System were required to master

70% of these skills to be promoted to the next grade level. Mastery of a skill was attained when a student answered three of the four test items on a particular skill correctly. Students were tested at the beginning of the year to find out what skills they had or had not mastered. Following this pretest students scoring at the lowest 10% of their class were identified as students who would require additional help in order to pass the posttest. In this study the students scoring at the lowest 10% of their class on the pretest were considered low achievers. In order to find out if the computer could aid these low achievers in developing their mathematics basic skills, principals in schools with computers were asked to permit students in their schools to participate in this study. The participating students from schools utilizing computers were identified as the experimental group. The control group was selected from similar schools. Students in the control group did not receive help by a computer.

School Selection

All elementary principals in the Knoxville City School System were contacted by telephone in order to ascertain which schools had access to Apple IIe computers. If the school had access to an Apple IIe computer, the researcher requested that they participate in this study. Initially, principals of 4 schools, out of the 10 which had been identified as having computers, agreed to complete the study. However, in one of the schools, students were not given sufficient computer time and for that reason could not be used in the final sample.

Several school principals refused to participate: these declined for two reasons. One reason given was that the school did not have their computer set up for student involvement. The second reason most often expressed was that the computer was so new to the school that sufficiently qualified personnel could not be identified to aid the students or the researcher. Three schools with computers agreed to become the experimental schools for this study. The Research and Public Relations Office of the Knoxville city schools identified three noncomputer schools which were similar in enrollment size. Students used for both control and experimental groups were comparable in socioeconomic levels. Community interest was also judged to be similar in control and experimental schools.

Student Selection

While students of all levels might benefit from computer aided drill and practice, the microcomputer seems especially beneficial to those students who need the most repetitive practice. Thus, the student population was limited to low achievers. Low achievers were identified as those students who had scored the lowest 10% of their fourth grade class on the Knoxville city school's pretest in mathematics basic skills. The fourth grade was selected for the study because promotion to the fourth grade required mastery of the third grade skills. An additional factor influencing the selection of the grade level was the availability of software. The available software in the Knoxville city schools was more appropriate to reinforce skills tested at the fourth grade level.

There were 17 students in the experimental group and 19 students in the control group. The control group had two students with exactly the same number of passed items on the pretest; therefore, both were included in the study. The participating students were from similar schools within the Knoxville City School System. Table 1 indicates the division of students in the experimental and control groups and the number of students from each participating school.

Table 1

The Division of Students in Experimental and Control Groups

<u>Experimental group</u>		<u>Control group</u>	
<u>School</u>	<u>Number of students</u>	<u>School</u>	<u>Number of students</u>
A	6	E	7
B	7	F	8
C	4	G	4

The Equipment

The Apple IIe computer was used in the research because this particular computer was the one type already in use in all of the experimental schools. This computer was also compatible with the software available to the Knoxville city schools through MECC. The following programs were used for the purpose of this study: Elementary 4 (Mathematics-Science), Mathematics Volume II (Measurement),

Elementary Volume 10 (Quadrilaterals--Area and Perimeter), Elementary Volume 1 (Mathematics Games and Drills). The Apple program called Supermath was also used in this research. It too was also available to all the experimental schools. Ten of the 23 mathematics skills tested in the Knoxville city schools' first semester mathematics basic skills test were reinforced by drill and practice programs on the computer.

Presentation

Treatment Common to Both Groups

All students participating in the study had to receive at least 1 hour of mathematics instruction each day in order to comply with the Knoxville city schools' guidelines and the requirements set by the State of Tennessee. The hour each day could be divided to include some teacher presentation, some time for discussion, and some time for drill and practice. Students in both experimental and control groups had the benefit of class instruction and discussion. The only major difference between the groups was that the experimental group utilized the microcomputer for some, but not all, of the daily 15 minutes (approximate) time allowed for drill and practice.

All students participating in the study utilized the Heath Mathematics textbook for the fourth grade level. Many paper and pencil activities were assigned from the accompanying Heath workbooks for both groups. However, fewer paper and pencil exercises were necessary for the computer group since drill for many skills was presented on the computer. Many of the textbook activities were also utilized to

teach the basic mathematics skills. Each teacher was supplied a list of skills to be tested and the corresponding page numbers for activities presented in the textbook. The daily lessons for each skill used by teachers of both control and experimental groups were correlated to Heath Mathematics Level 4, the textbook adopted by the Knoxville city schools. The teacher's edition of that text provided common lesson plans. Those lessons are correlated with the specific first semester fourth grade skills on the Mathematics Basic Skills Test. Table 2 presents a correlation between the Knoxville city schools basic skills and practice activities in the Heath mathematics textbook.

The Knoxville city schools also employed Basic Skill Teachers who did not teach in the regular classroom but provided the classroom teachers with materials designed to aid them in the instruction of basic mathematics skills. Most of the activities provided by these special teachers were paper and pencil activities. The students in the experimental group completed some of the pencil and paper activities but individualized some of their drill time by utilizing the microcomputer.

Experimental Group

Each of the students in the experimental group was given $1\frac{1}{2}$ hours a week of drill and practice using the computer for mathematics basic skills. The experimental group utilized computer drill in place of some of the workbook assignments on the skills for which computer drill was available. If computer drill was not available for a particular skill, the skill was not included in the study. The particular time and specific skills needing practice were identified by the classroom

Table 2

Mathematics Correlation of Knoxville Objectives to Heath Text Grade 4--First Semester

Skill No.	Basic Mastery	References
1	Identifies word names for numerals and changes word form to numerals and vice versa (0-9,999,999).	Ch. 2, pp. 22-23, 26-31, 36-38, 40, 42
2	Identifies place value and the value of a digit in numerals (0-9,999,999) and writes the expanded form using place value chart.	Ch. 2, pp. 22-23, 26-29, 33, 36, 38, 40, 42 practice 326-327
3	Compares numbers using symbols greater than, less than, and equals with numerals (0-99,999).	Chs. 2, 3; pp. 32-33; practice 65, 326-327
4	Rounds a given number to the nearest 10, 100, 1000, or 10,000.	Chs. 2, 3; pp. 24-25, 34, 50-51, 64, 65 practice 326, 327
5	Writes a proper fraction, fraction, or mixed number for shaded or pictured objects (denominators no larger than 25).	Ch. 6, pp. 136-141, 168-170, 172, 174-176 practice 172, 174, 176, 333
6	Defines the following terms: addend, sum, minuend, subtrahend, difference.	Ch. 1, pp. 2, 6-11
7	Identifies and uses addition and subtraction properties of zero.	Ch. 1, p. 4
8	Adds two numbers (each 999 or less) with no regrouping, nonconsecutive regrouping, or consecutive regrouping.	Ch. 3, pp. 44-52, 74, 76 practice 5, 25, 76, 83, 169, 193, 207, 325, 328
9	Adds four 3-digit numbers with or without regrouping.	Ch. 3, pp. 54-55 practice 329
10	Subtracts numbers (each 9999 or less) with no regrouping, nonconsecutive regrouping, or consecutive regrouping.	Ch. 3, pp. 58-65 practice 31, 51, 76, 123, 169, 183, 213, 326, 329-330
11	Subtracts numbers (9999 or less) with regrouping involving minuends with one, two, or three zeros.	Ch. 3, pp. 61-67 practice 76, 169, 183, 213, 326, 329-330
12	Adds or subtracts when parentheses are used to indicate the order of operations using number (0-999).	Chs. 3, 5; pp. 70, 124 practice 242
13	Adds and subtracts decimals in the form of money, with and without regrouping.	Ch. 3, pp. 49, 55, 61, 63 practice 74
14	Defines and identifies the following terms: factor and product.	Ch. 5, p. 98
15	Identifies and uses the multiplication property of zero and demonstrates an understanding of the role of zero in division.	Ch. 5, p. 106
16	Names the numerator and denominator in a fraction.	Ch. 6, p. 136

Table 2 (continued)

Skill No.	Basic Mastery	References
17	Writes the relationship among seconds, minutes, hours, days, weeks, and years.	Ch. 4, pp. 80-85 Teacher must provide additional materials.
18	Indicates equivalencies for denominations of money (penny, nickel, dime, quarter, half-dollar, dollar, five dollar and ten dollar bill).	Ch. 4, teacher p. 86
19	Determines the value of a collection of coins and/or bills (\$20.00).	Ch. 4, pp. 86-90
20	Solves simple open sentences with missing minuends and subtrahends.	Teacher must provide lessons and materials.
21	Completes simple number patterns by giving numbers that come before, after, or between, or that continue a pattern of repetition.	Teacher must provide lessons and materials.
22	Uses addition and subtraction (0-9999) to solve one-step story problems with regrouping.	Ch. 3, pp. 68-69, 72, 73 Extra practice 345-349
23	Estimates and determines the appropriate amount of change due from a ten-dollar bill on purchases (\$.01-\$9.99).	Ch. 4, pp. 88-89

teacher according to the results of each child's pretest. The classroom teacher chose from among the available software the program or programs most appropriate for each individual student. Titles of computer programs used in this study are listed in Table 3.

The scheduling of time the child spent on the computer was arranged to suit the student's needs. Actual time schedules of individual computer work varied from student to student and from school to school. Some students arrived at school early because of bus schedules. These students began their work as soon as they arrived. Some students worked on the computer at varied times in the school day including independent work time, while the teacher was working with other children. The programs on the computer did not require the teacher's participation for the instruction. Therefore, once the programs were identified, any time available to the child for independent practice could be a time scheduled at the computer.

One school scheduled students for computer drill for 15 minutes each morning with an additional 15 minutes on Friday afternoon. The students not scheduled at the computer spent the same amount of time on paper and pencil drill. Another school scheduled students for computer drill each morning for 18 minutes while the remainder of the class worked on paper and pencil drill and practice activities. Since there were only two apple computers in each school, not all students were working on the computers at the same 15 minute time period. All experimental schools divided their morning activities to include grouping for instruction. The time scheduled at the computer would be a

Table 3

Titles of Computer Programs Used in this Study

Elementary Vol. 1 MECC #702	Elementary 4 (math/science) MEC #705	Mathematics Vol. 11 MECC #737	Elementary Vol. 10 MECC #734
1. Bagles (number guessing) 2. Change (cash register) 3. Hurtle 4. Metric Estimate 5. Metric Length 6. Metric 21 7. Number 8. Round 9. Speedrill 10. Taxman 11. Tens	1. Estimate 2. Math Game 3. Odell Lake 4. Odell Woods 5. Solar Distance 6. Ursa	1. Conversion lesson 2. Liquids 3. Length 4. Weights 5. Addition Lesson 6. Addition Drill 7. Subtraction Lesson 8. Subtraction Drill 9. End	1. Quadrilaterals 2. Quiz on Quadrilaterals 3. Area and Perimeter 4. Quiz on Area and Perimeter 5. End

time the child would have engaged in some sort of paper and pencil drill often referred to as seatwork. The students spent part of their morning in group instruction, part in learning center activities, and part in independent seatwork. All students completed all three activities even though not all groups were engaged in the same activity at the same time. Table 4 gives a sample of a schedule.

Table 4
Sample Schedule

	Monday	Tuesday	Wednesday	Thursday	Friday
Morning mathematics					
18 minutes of independent practice	review drill	drill on lesson A	drill on lesson B	drill on lesson C	drill on lesson D
Afternoon mathematics					
Classes (42 minutes)	lesson A	lesson B	lesson C	lesson D	lesson E

The computer instruction and practice time for students in the experimental group was provided over a period lasting 12 weeks during the 1983-84 school year. At the end of this time the students were given the Knoxville city school's posttest in mathematics basic skills. All students improved in obtaining mastery of their basic skills.

The Control Group

Students in the control group were given no special treatment during the period of the study. That is to say, no common activities

were designed as part of the study. The amount of instruction and practice varied depending upon the individual class and teacher. That these students spent comparable time to the students in the experimental group in drill and practice was considered verifiable due to the standards set by the State of Tennessee which requires all students to spend 5 hours a week in mathematics instruction. Further assurance is given by the following common practices in the Knoxville city schools. Scores on the pretest were known to these teachers and students. Teachers were expected to provide whatever help the students needed in order to master the skills on the posttest. Parent conferences, peer-tutoring, paper and pencil drill and practice, and teacher-made drill and practice on specific skills were the typical approaches used with children considered to be behind in their skills. Students in the control group did not receive drill and practice on a microcomputer, but did receive conventional drill and practice as part of their mathematics instruction.

Classroom Observation

The researcher was a teacher in one of the experimental schools. The following paragraph summarizes comments made to her during the time of the study.

The students who participated enjoyed the lessons on the computer and asked if they could stay after school to "play" on the computer more. A number of students also expressed a desire for additional computer programs. Several students said that they liked "math" on the computer better because they didn't have to write down

the problems or the answers. One child said that it was still the same old "math" but on the computer it wasn't as ~~bad~~ as doing problems from the book. None of the children expressed any negative feelings for practicing mathematics skills on the computer.

Descriptions of Computer Programs

Table 5 identifies 10 of the computer programs used in the study. These were the programs the researcher deemed most beneficial in aiding the experimental group to master their skills. The table shows the programs identified by the names as they appear on the menu for each diskette. The other part of the table describes the skills addressed by each of the programs.

Round Program

The Round Program was used to help students practice the skill of rounding numbers to the nearest 10, 100, or 1,000. The computer program gave students a choice of whether they wanted to practice rounding to the nearest 10, 100, 1,000, or a random mixture. The students were also given a choice on the amount of practice problems that the computer would display. When the computer displayed a number, the student answered by "punching in" the correct answer on the keyboard. The computer feedback contained the word "good" or some other word of praise if the answer was correct. Students were given two opportunities to answer the question. If the child's first answer was incorrect the computer responded by telling the student

Table 5

Basic Skills and Applied Computer Programs

Skill No.	Skill	Programs applied
4	Rounds to tens, hundreds, thousands	1. Round from #702 MECC
8	Adds two numbers (9999 or less)	2. Speedrill from #702 MECC Math game from #705 MECC Supermath from Apple Company
10	Subtracts numbers (9999 or less)	3. Speedrill from #702 MECC Math game from #705 MECC Supermath from Apple Company
11	Subtracts numbers (9999 or less) with zeros in minuend	4. Speedrill from #792 MECC Math game from #705 MECC Supermath from Apple Company
13	Adds and subtracts decimals in the form of money	5. Change from #702 MECC
15	Understands the role of zero in multiplication and division	6. Supermath from Apple Company Tens from #702 MECC
16	Names numerator and denominator in a fraction	7. The darts program from Supermath of Apple Company
18	Indicates equivalencies for coins and bills (through \$10.00)	8. Change from #702 MECC
19	Determines the value of a collection of coins and bills (\$20.00)	9. Change from #702 MECC
23	Estimates and determines change due from 10-dollar bill	10. Change from #702 MECC

(The skills are taken from a list of 23 skills tested on the Knoxville city schools' first semester posttest.)

that his answer was either too large or too small. This was followed by the words "try again." After the second attempt the student was given the correct answer. When the student had completed all the practice problems the computer displayed the score. The total number of questions attempted and the number correct on the first and second tries were displayed on the screen. No display was made for the number wrong. After the score was given students were given the opportunity to choose either to play again or to choose another program on the menu.

Speed Drill

Speed Drill was used to help students in computation skills involving all four mathematical operations (add, subtract, multiply, and divide). The program had three difficulty levels and three speed levels. The speed levels were chosen on the basis of how much time was permitted for each answer. The amount allowed for response could be 10, 8, or 6 seconds. The difficulty levels ranged from single digit computation to double digit computation involving regrouping. The computer displayed various examples on the screen. Students were given two opportunities to answer. The number answered correctly on the first and second tries were displayed at the end of the questioning. Students were also given points for how fast the questions were answered. Students were challenged to reach the perfect score of 1,000 points.

Tens

Tens provided drill in multiplying number which were multiples of 10. The program aided students in understanding the role of zero in multiplication. Printed responses were displayed on the screen to inform the student whether the answer was correct. Two opportunities were given for each question. At the end of the questioning students were given the number correct on each try. At the end of the program students were given a choice between repeating the program or choosing another program on the diskette.

Change

Change dealt with money and did exactly as the name implies. This program helped students make correct change. Students were given a purchase amount and the amount received as payment. The student responded by answering how much change was due. The computer screen displayed a grid representing the inside of a cash register drawer. The students were asked several questions pertaining to how many pennies, dimes, and dollar bills were needed for the change. The student answered each question by placing the correct number of each coin or bill needed for the customer's change. If the student answered with the correct amount, but did not give the change in the most efficient manner, the computer accepted the answer but printed that there was a more efficient way to make the change. The student could either try again or choose to let the computer display the more efficient answer. This program aided the students in

the comprehension of several skills. It helped students determine the value of coins and bills. The program required students to understand the subtraction of decimals in the form of money and give the equivalencies of coins and bills. The student was also required to know what change was to be given to the customer.

Math Game

The program was designed to accommodate one or several children. This program aided students in basic computation skills involving one or two digit numbers. Students had a choice of operations on whole numbers and a choice of difficulty level. The program allowed each student three opportunities to answer correctly. After three incorrect tries the computer displayed the correct answer on the screen. The students were given their scores at the end of each question. The score was based on how many attempts were required, and the amount of time required for the correct answer. A score of zero was given if the child could not correctly answer after three attempts. At the end of the program the final score for each player was given with the winner's name at the top of the screen.

Darts

This drill was patterned after a carnival dart game. The player attempted to strike a balloon with a dart by estimating the correct fractional number. The game also reinforced the mathematical terms numerator and denominator. The student must respond to the visual cue for each term in order to place the correct numeral in the response.

Supermath

This program was another drill on the four operations on whole numbers. Each operation had a variety of levels. The addition and subtraction sections each had 99 levels. The student was branched to higher levels when correct answers were given and to lower levels when too many mistakes were made. The program allowed the student three opportunities to answer correctly. If the student did not get the answer correct after three attempts the computer displayed the correct answer with words of encouragement and directions for answering the question correctly. The student needed to press the escape key on the computer to end the program. A percentage score was displayed at the end of the program.

The Supermath program also allowed students to practice each operation with one specific numeral at a time. If the student chose multiplication and the numeral 5 then all the questions given would drill the student on multiplication using the numeral 5. The student could practice any numeral on any of the four operations he/she desired. Ideally the student would practice the basic fact he/she was having the most difficulty learning.

CHAPTER 4

RESULTS

Introduction

In the 1983-84 school year a study was conducted to determine the effect of drill and practice on a microcomputer and mastery of mathematics basic skills. The study was conducted with six of the Knoxville city schools. The subjects were low achieving fourth grade mathematics students. Students considered low achievers for this study were those students who scored among the lowest 10% of all the fourth graders within their particular school on the city administered fourth grade mathematics basic skills pretest. In three schools drill and practice on a microcomputer was used to help students deficient in skills. In the other three schools traditional methods were utilized with students deficient in skills. The students receiving computer drill and practice comprised the experimental group. Students receiving traditional drill and practice typically, paper and pencil activities or teacher-made skill centers, comprised the control group. Both groups received the same amount of teacher instruction as the State of Tennessee required a minimum of 1 hour a day for mathematics. The major difference between groups was the computer drill and practice.

Observation

During the 12 weeks of the study in which the students participated in the drill and practice on the computer, the researcher

received many positive reports from students and principals. Many students said that they liked knowing right away whether or not their answers were correct. Others said that it was more fun to work on the computer because it (the computer) writes the problems. Some students asked if they could stay after school to "play" on the computer, or if they could "play" on the computer instead of going outside at recess. Principals also reported that they noticed the positive motivational effects in students from using the computer. No discipline problems or avoidance behavior was reported to the researcher while students were participating in the computer drill and practice. One principal did comment that more software should be available because near the end of the study some students had requested more "games." These students apparently considered mathematics drill on the computer as a game. One principal purchased additional software for the next school year attributing motivational effects and mathematics achievement to the computer. For the duration of the study student attitudes toward the computer drill were observed as positive.

Analysis of Student Performance (Analysis of Covariance)

When the researcher cannot select random groups that are essentially equal, statistical corrections must be made to allow for such differences (Bruning & Kintz, 1977, p. 192). An analysis of covariance was the statistical procedure used in this study.

The analysis of covariance utilizes the relationship between the dependent variable [the posttest] and an independent quantitative variable [the pretest] in order to reduce experimental errors and make the experiment a more

powerful one for studying treatment effects. The use of regression relationships in covariance analysis may be thought of as an indirect means of controlling experimental errors. (Neter & Wasserman, 1974, p. 686)

The analysis of covariance was completed utilizing the computer at the University of Tennessee, Knoxville, for the mathematical computation. The computer results are in Appendix A. The only skill that obtained the .05 significance level was skill #19 (the learner will determine the values of coins or bills up to 20 dollars). The difference between the groups may appear to be in favor of the experimental group but cannot be viewed as statistically significant. A discussion of each skill for which there was computer treatment is in the following section.

Analysis of Computer-Treated Skills

The computer software addressed 10 of the mathematics skills tested. The first basic skill involved rounding number to tens, hundreds, or thousands. The students who received the computer treatment did slightly better than the control group on this skill. Table 6 gives the means, the mean differences, and the covariance. The mean difference represents the difference between the mean on the pretest and the mean on the posttest for each group. The mean difference for the experimental group was 1.18. The mean difference for the control group was 1.05. According to the analysis of covariance this was not a significant difference. The experimental group had a gain of .12 more than the control group at a significance level of .72.

Table 6

Results of an Analysis of Covariance Between Pretest and Posttest Scores on the Knoxville City Schools Fourth Grade Mathematics Basic Skills Test

Skill no.	PRE $\bar{X}$	S.D.	POST $\bar{X}$	S.D.	Difference	Covariance
4E	1.35	1.93	2.53	1.79	1.18	.72
4C	1.47	1.07	2.53	1.07	1.05	
8E	2.06	1.25	3.71	.59	1.65	.61
8C	1.74	.99	2.84	1.30	1.05	
10E	.65	.70	3.35	1.06	2.71	.11
10C	1.05	.94	2.32	1.77	1.26	
11E	.59	.71	3.29	1.26	2.71	.18
11C	.95	.85	2.84	3.02	1.89	
13E	1.24	1.21	2.88	1.05	1.65	.06
13C	.68	.89	2.37	1.30	1.68	
15E	1.76	1.15	2.82	.88	1.06	.25
15C	1.42	1.22	2.58	1.02	1.16	
16E	1.29	.77	2.35	1.50	1.06	.58
16C	1.37	.83	2.58	1.07	1.12	
18E	1.47	1.01	2.94	1.09	1.47	.58
18C	1.32	.67	2.47	1.31	1.16	
19E	1.47	1.18	3.36	.87	1.89	.04*
19C	2.26	1.24	3.00	1.11	.74	
23E	1.00	.87	2.06	1.20	1.06	.14
23C	.58	.69	1.53	.84	.95	

E = Experimental Group

C = Control Group

*Significance

A second computer-treated skill involved the addition of two numbers (four-digit numbers or less). Again the experimental group improved slightly more than the control group. The mean difference for the experimental group was 1.65. The mean difference for the control group was 1.05. A very slight difference between the two treatments favored the experimental group but not significantly. Both treatments helped students learn to add two numbers.

The experimental group also improved slightly more than the control group in subtracting two numbers (four digits or less). The mean difference for the experimental group was 2.71. The mean difference for the control group was 1.26. The experimental group showed more improvement in this skill than the previous two skills but still not a significant difference.

With the subtraction skills numerals with four digits or less were also included. However zeros appeared in the minuend. The experimental group improved slightly more than the control group in this skill. The mean difference for the experimental group was 2.71. The mean difference for the control group was 1.89. This difference was not significant according to the statistical analysis of covariance.

The control group added and subtracted money in the form of decimals slightly better than the experimental group. The difference was not significant. An explanation of the slight difference favoring the control group might be the method by which the choices were recorded on the posttest. The choices gave the numerically correct answer in several of the choices but used both the dollar and the cent signs. The students using the computer drill did not have practice

using the double signs. The courseware was designed to have the students give the correct amount of change and the correct number of coins or bills. The mean difference for the control group was 1.68 and the mean difference for the experimental group was 1.65. The significance level was .06.

The control group also performed better on the skill item to assess understanding the role of zero in multiplication and division than did the experimental group. The experimental group had had practice multiplying and dividing using the zero. Nonetheless, two of the four test items were descriptive verbal questions rather than computation with zero. In one example question students were asked to choose from among four choices the statement that was true. The correct response required that the students choose, "A number cannot be divided by zero." Another question required that the students choose the correct property of zero for a given equation. (The equation $27 \times 0 = 0$ shows _____ ? _____.) Many students were confused over the use of the word equation. Also the students had not been required to refer to multiplication with the zero as the multiplication property of zero on any of the computer drills. The difference in mean scores again was not significant. The control group had a mean difference of 1.16 while the experimental group scored a mean difference of 1.06. It might be speculated that the experimental group would have done better if all four test questions had simply required computation with zero.

The control group also did better in naming the numerator and denominator in fractions. Once again the difference was not

statistically significant. The control group had a mean difference of 1.12. The experimental group had a mean difference of 1.06. The slight difference between the groups might be attributed to the fact that the "darts program" was the only program used by the experimental group to utilize these particular terms. This program constantly listed the numerator first. The students may not have paid as much attention to the vocabulary once the pattern of the game was familiar. There was no statistically significant difference between the groups. Both types of drill were considered effective.

The experimental group indicated equivalencies for coins and bills better than the control group. The mean difference for the experimental group was 1.47. The mean difference for the control group was 1.16. The difference was not considered significant by the analysis of covariance. The difference between the groups might have been more significant if the test questions were common coin exchanges. For example the number of nickels in a dime, or the number of pennies in a nickel. The test questions asked for equivalencies not in usual monetary exchanges. For example, the number of dimes equivalent to 12 nickels, and the number of quarters for 10 nickels. The experimental group performed slightly better than the control group but the difference was not statistically significant.

The experimental group determined the value of a collection of coins or bills significantly better than the control group. The mean difference for the experimental group was 1.15. The mean difference for the control group was .74. The computer drill significantly helped

the students on this particular skill. The "change program" required the student to know the value of coins and bills to successfully complete several subquestions as part of the larger problem of correctly making change. The student was asked every time the number of pennies, nickels, dimes, and quarters which were required for the change. Paper and pencil activities often only ask for the numerical figure with the correct decimal and sign. Often such activities do not include questions about the value of the coins and bills required for the change. The computer drill was significantly superior to traditional methods for this particular skill.

The experimental group also performed slightly better in estimating and determining change due from a 10 dollar bill. However the difference between the groups was not significant at the .05 level. The experimental group had a mean difference of 1.06. The control group had a mean difference of .95. The test questions did not require exact answers but rather estimates only. Students had to choose the closest answer from among four choices. The computer program had not given drill in estimating change. The computer drill required exact answers. The difference between the groups might have been more significant if exact answers were required.

Analysis of Student Performance (Percentage Basis)

At the conclusion of the 12 week treatment both experimental and control groups were given the fourth grade first semester mathematics posttest required by the Knoxville city schools. Twenty-three skill items were tested. The test included four questions for each skill

item. To achieve mastery of the skill the student correctly answered three of the four questions. In this study the experimental group had received computer drill on 10 of the 23 items tested. The control group had received whatever traditional drill deemed necessary by their classroom teacher. The results of the posttest measured on a percentage basis show superior mastery for the experimental group.

On the 10 items in which the experimental group received computer drill, 65% of these low achievers mastered the skills. On these same 10 items only 37% of the control group mastered the skills. Even though the computer did not specifically drill other items on the test, mathematics concepts needed for mastering these items may have been a part of this learning as well. For instance, vocabulary identification was not a part of the drill; however, much of this mathematical vocabulary could have been used with students as they worked on the computer. The average number of skills passed by the experimental group was 16.5 or 17 skills. The average number of skills passed by the control group was 12.2 or 12 skills. The experimental group had 70% of the students mastering 15 or more skills on the posttest while only 42% of the control group mastered 15 skills or better. In viewing the percentage results, the experimental group yielded a greater number of students mastering the skills than the control group.

Overall Results

Based on the statistical analysis of the data as well as observed differences in the performance of the experimental and control groups the following might be seen as the basic findings of the study.

1. The only significant difference between experimental and control groups was on skill #19 (the learner will determine the value of coins or bills to \$20.00). The experimental group performed better on this skill than did the control group at the .05 significance level.
2. In all other skills there was no statistical significant difference favoring either the experimental or the control group.
3. A greater percentage of the students in the experimental group mastered the required number of mathematics basic skills.
4. Students were observed to have a high level of motivation for drill on the computer.
5. The experimental group performed slightly better than the control group on six of the skills, significantly better on one skill, and slightly less well than the control group on three of the skills.

CHAPTER 5

SUMMARY, FINDINGS AND DISCUSSION

Introduction

In the 1983-84 school year a study was conducted to determine the effect of drill and practice on a microcomputer and mastery of mathematics basic skills. The study was conducted with six of the Knoxville city schools. The subjects were low achieving fourth grade mathematics students. Students considered low achievers for this study were those students who scored among the lowest of 10% of all the fourth graders within their particular school on the city administered fourth grade mathematics basic skills pretest. In three schools drill and practice on a microcomputer was used to help students deficient in skills. In the other three schools traditional methods were utilized with students deficient in skills. The students receiving computer drill comprised the experimental group. Students receiving traditional drill, such as paper and pencil activities or teacher-made skill centers, comprised the control group. Both groups received the same amount of teacher instruction as the state of Tennessee requires a minimum of one hour a day for mathematics. The major difference between groups was the computer drill.

Findings

The following statements can be supported from the data reported in Chapter 4.

1. The only significant difference between experimental and control groups was on skill #19 (the learner will determine the value of coins or bills to \$20.00). The experimental group performed better on this skill than did the control group at the .05 significant level.
2. In all other skills there was not statistical significant difference favoring either the experimental or the control group.
3. A greater percentage of the students in the experimental group mastered the required number of mathematics basic skills.
4. Students were observed to have a high level of motivation for drill on the computer.
5. The experimental group performed slightly better than the control group on six of the skills, significantly better on one skill, and slightly less well than the control group on three of the skills.

Discussion

The findings related to the performance of the experimental and control groups may be explained in part by factors outside those variables controlled in the study. The experimental group did not show growth significantly superior to the control group on the mathematics basic skills test. One factor involved in this might have been the small number of items on the test for each skill tested. Four items

simply might not have been an adequate number for differences to be identified. Perhaps the most telling factor though may relate specifically to the quality of the computer software used in the study. The software had not been specifically designed for the express purpose of improving those mathematics skills measured by the test. The software quality itself might be questioned. Software development for mathematics is still in what might be identified as the pioneer stage. It needs to be emphasized that the researcher used available software in the Knoxville city schools. There was little variety from which to choose; but it is possible that there was little variety on the market at the time of the study which addressed these skills. It may be predicted that in the future the burgeoning computer industry will produce both greater variety and improvement in quality of software.

Even with these limitations the experimental group did at least as well as the control group on the skills for which computer programs were available. Because the use of microcomputers was relatively new in the field of education much of the available software had not been researched with regard to educational value. The MECC software had been used in the State of Minnesota for educational purposes and offered some of the best programs available in the 1983-84 school year even though the scope of these programs did not offer drill on all the necessary skills.

Although drill and practice on the microcomputer could not be credited for greatly improving the scores of the experimental group on the Knoxville city schools' mathematics basic skills test it did show

some possibilities for future use. The computer provided an alternative way to individualize instruction for students needing drill on specific skills. Individualization might also be provided for gifted students by introducing new skills via the computer. The computer drill could save the teacher time because the computer checks the student's work and also has the capability for giving minor corrections as the student requires them. The computer is highly motivational for most students and may make learning more enjoyable. The computer is also capable of managing individualized instruction which can free the teacher from management tasks to provide more teaching and planning time. While the study did not show statistically significant improvement favoring the experimental group on the Knoxville city schools' mathematics basic skills posttest, students in the experimental group did improve about as well or slightly better than those in the control group. The researcher believes that this study has shown the computer can be used as an effective educational tool for helping students master mathematics basic skills. The researcher would also contend that the limitations of the microcomputer may be inherent in the amount and quality of available software for computer-assisted instruction. Perhaps future research will show more statistically significant mathematics achievement for computer use as the quantity and quality of educational software improves.

The use of drill and practice is only as effective as the initial instruction. Most educators acknowledge that drill on mathematic skills without appropriate instruction would not benefit the student. Sometimes within a class a small number of students can misunderstand the

instruction and complete a whole assignment of pencil and paper drill without being corrected until the next day or whenever the papers are corrected and returned. The microcomputer has the capacity to give immediate feedback to the study and minor corrections or examples for the student to follow. Therefore the microcomputer virtually eliminates the possibility of students completing a number of problems incorrectly without receiving any feedback. The unique feature of immediate feedback provided by the microcomputer on mathematics drill and practice would certainly aid students in the completion of effective mathematics drill.

A notable outcome of this study was the way in which it was perceived by the administration of one particular school. Because of the perceived success and student motivation additional software, better suited to the needs of an entire school for mathematics drill, was purchased for one of the experimental schools the following year. All students in grades 1 through 5 in that school received computer mathematics drill for 30 minutes a week throughout the 1984-85 school year. The students came to the computer room, which was organized much like a computer laboratory. There was a teacher trained and experienced in computer use to assist the students. In each class group there were as many students as there were microcomputers. According to the principal, the students in that school showed improvement in both a mathematics basic skills test and a standardized achievement test over scores for the previous year. The principal attributed the higher scores to the use of the computer.

Many people perceive the computer to be a tool by which mathematics achievement may be improved. The computer may offer a more entertaining and motivational approach to the necessary mathematics drill, and in that way attract students to spend more time on completing assignments via the computer. Only further research can answer the many questions raised by the effects of the microcomputer on mathematics achievement in basic skills.

More research needs to be done related to the instructional use of the microcomputer. Although results favoring computer use were found in earlier research on the minicomputer and mainframe computers, it cannot be assumed for several reasons that the microcomputer is as effective in CAI as the mainframe or minicomputer without further research. One of the big differences is that a minicomputer laboratory usually accommodates a class of students for 10 to 20 minutes and does not require the supervision of the classroom teacher, but has a trained director of the computer laboratory instead. When a microcomputer is added to a classroom, it usually accommodates only one or two children at a time and the classroom teacher is responsible for both the students utilizing the computer and the remaining students in the class. The microcomputer cannot accommodate complete sets of CAI programs such as those associated with Computer Curriculum Corporation or PLATO. Because of the reduced storage capacity currently available on microcomputers, existing CAI courseware used with large computers would have to be modified or broken down into component parts to be usable with the microcomputer (Ragosta, 1983, p. 125).

The effectiveness of CAI is dependent on the courseware available and much of the researched courseware was not available for use on the microcomputer; therefore, it would certainly be recommended that research be conducted to determine whether curricular changes in the CAI courseware, making it more compatible to school curriculum and to microcomputers, could increase or decrease the effectiveness of computer drill and practice. This study needs to be replicated with a larger sample taken from a larger number of schools. Neither this study nor any existing research has dealt extensively with the variety of microcomputer capabilities and the attendant learning-thinking that students might do while using microcomputers.

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APPENDIX

Table A-1

Results of Computer Analysis of Covariance Between Pretest and Posttest Scores on the Knoxville City Schools Fourth Grade First Semester Basic Skills Test

Skill* No.	DF	Type I SS	F Value	PR > F	DF	Type III SS	F Value	C.V. PR > F
1 Code	1	3.07	2.66	0.11	1	3.28	2.85	0.10
Post1	1	3.65	3.16	0.08	1	3.64	3.16	0.08
2 Code	1	2.09	3.15	0.09	1	2.08	3.13	0.09
Post2	1	0.00	0.00	0.99	1	0.00	0.00	0.99
3 Code	1	3.04	2.39	0.13	1	5.13	4.04	0.05
Post3	1	11.23	8.84	0.01	1	11.23	8.84	0.01
4 Code	1	0.13	0.13	0.72	1	0.13	0.13	0.72
Post4	1	0.86	0.84	0.37	1	0.86	0.84	0.37
5 Code	1	0.51	0.27	0.61	1	1.42	0.74	0.40
Post5	1	2.43	1.27	0.27	1	2.43	1.27	0.27
6 Code	1	0.00	0.00	0.99	1	0.00	0.00	1.00
Post6	1	0.00	0.00	0.99	1	0.00	0.00	0.99
7 Code	1	0.76	0.35	0.56	1	1.79	0.83	0.37
Post7	1	2.80	1.30	0.26	1	2.80	1.30	0.26

Table A-1 (continued)

Skill* No.	DF	Type I SS	F Value	PR > F	DF	Type III SS	F Value	C.V. PR > F
8								
Code	1	0.93	0.73	0.40	1	0.35	0.27	0.61
Post8	1	0.56	0.44	0.51	1	0.56	0.44	0.51
9								
Code	1	1.32	1.08	0.31	1	0.06	0.05	0.82
Post9	1	5.03	4.10	0.05	1	5.03	4.10	0.05
10								
Code	1	1.48	2.00	0.17	1	1.96	2.66	0.11
Post10	1	0.51	0.69	0.41	1	0.51	0.69	0.41
11								
Code	1	1.16	1.82	0.19	1	1.22	1.92	0.18
Post11	1	0.07	0.11	0.74	1	0.07	0.11	0.74
12								
Code	1	0.12	0.10	0.76	1	0.00	0.00	1.00
Post12	1	0.72	0.55	0.46	1	0.72	0.55	0.46
13								
Code	1	2.72	2.50	0.12	1	3.98	3.65	0.06
Post13	1	3.15	2.89	0.10	1	3.15	2.89	0.10
14								
Code	1	1.69	2.33	0.14	1	1.68	2.33	0.14
Post14	1	0.00	0.00	0.97	1	0.00	0.00	0.97
15								
Code	1	1.91	1.42	0.24	1	1.81	1.35	0.25
Post15	1	0.03	0.02	0.88	1	0.03	0.02	0.88

Table A-1 (continued)

Skill* No.	DF	Type I SS	F Value	PR > F	DF	Type III SS	F Value	C.V. PR > F
16								
Code	1	0.05	0.08	0.78	1	0.08	0.12	0.73
Post16	1	0.41	0.63	0.43	1	0.41	0.63	0.43
17								
Code	1	0.00	0.00	0.99	1	0.00	0.00	0.97
Post17	1	0.15	0.14	0.71	1	0.15	0.14	0.71
18								
Code	1	0.09	0.14	0.71	1	0.21	0.31	0.58
Post18	1	0.28	0.41	0.53	1	0.28	0.41	0.53
19								
Code	1	5.64	3.81	0.06	1	6.68	4.52	0.04
Post19	1	1.16	0.79	0.38	1	1.16	0.79	0.38
20								
Code	1	1.39	1.46	0.24	1	1.48	1.56	0.22
Post20	1	0.17	0.18	0.68	1	0.17	0.18	0.68
21								
Code	1	0.83	0.78	0.38	1	1.46	1.38	0.25
Post21	1	5.47	5.17	0.03	1	5.47	5.17	0.03
22								
Code	1	4.32	4.28	0.05	1	4.07	4.04	0.05
Post22	1	0.64	0.64	0.43	1	0.64	0.64	0.43
23								
Code	1	1.59	2.54	0.12	1	1.46	2.34	0.14
Post23	1	0.00	0.00	0.96	1	0.00	0.00	0.96

*The skill numbers are the same as those listed in Table 3, p. 38. The skill is specified in Table 3 for further reference.

VITA

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