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I am submitting herewith a dissertation written by Robert Lloyd Davidson entitled "The Effectiveness of Computer Assisted Instruction of Chapter I Students in Secondary Schools." 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.

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THE EFFECTIVENESS OF COMPUTER ASSISTED INSTRUCTION OF
CHAPTER I STUDENTS IN SECONDARY SCHOOLS

A Dissertation
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Degree
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ABSTRACT

The major purpose of this study was to determine the effectiveness of computer assisted instruction in the mathematics classroom. Mathematics achievement scores of Chapter I students receiving only traditional instruction were compared to mathematics achievement scores of Chapter I students using computer assisted instruction. Chapter I students from grades 9, 10, 11, and 12 at Fulton High School, Knoxville, Tennessee, were chosen. Form J of the Metropolitan Instructional Mathematics Test was administered to establish the initial level of students' mathematical achievement. Thirty-six students were in the control group and 18 were in the experimental group. The 18 students in the experimental group utilized computers in mathematics instruction and the 36 students in the control group did not use computers. To control for variation, each group was taught by the same teacher, used the same textbooks, curriculum guide and materials. Both groups were tested after a 13-week program by the Metropolitan Instructional Mathematics Test, Form J. The scores of both the computer assisted instruction group and the control group were compared by using an Analysis of Covariance. The results of this analysis indicated that computer assisted instruction

did not result in significant gains in mathematics achievement of Chapter I students.

TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
Statement of the Problem	6
Procedures	7
Assumptions	8
Limitations	9
Delimitations	10
Definition of Terms	10
Organization of the Study	12
II. REVIEW OF RELATED LITERATURE AND RESEARCH . .	13
Introduction	13
Assets of Computer Assisted Instruction . .	14
Learning Theories and Strategies Associated with Computer Assisted Instruction . .	19
Courseware Modes	28
Drill and Practice	28
Tutorials	31
Simulation	33
Demonstration	36
Instructional Games	37
Software Evaluation	40
III. EXPERIMENTAL DESIGN AND METHODOLOGY	52
Introduction	52
School and Community	52
Subjects	53
Treatments	54
Procedures	55
Software Description	58
Research Design	59
Instrument	59
Design and Statistical Analysis	61
Collection of Data	62
IV. PRESENTATION AND INTERPRETATION OF RESULTS . .	64
Introduction	64
Presentation of Data	67
V. SUMMARY, FINDINGS, DISCUSSION, AND RECOMMENDATIONS	&)

CHAPTER	PAGE
Summary	70
Findings	71
Discussion	72
Recommendations	75
REFERENCES	77
APPENDICES	82
A. CONSENT LETTERS	83
B. INSTRUCTIONAL FORMAT	88
C. WEEKLY LOG REPORT	92
D. COMMERCIAL SOFTWARE USED	94
E. OUTLINE OF THE ADVANCED 1 MATHEMATICS INSTRUCTIONAL TEST, FORM J	97
VITA	101

LIST OF TABLES

TABLE	PAGE
I. Summary of F Value for Control and Criterion Variable	65
II. Posttest Means of Mathematics Achievement Score Table Adjusted for Covariant	65
III. Means of Mathematics Achievement Score Table for Control and Experimental Groups Before Adjustment for Covariant	66
IV. Attrition for the Control and Experimental Groups	66

CHAPTER I

INTRODUCTION

The profession of education has undergone many recent changes. The most dramatic change has come from the use and influence of computers on today's educational society. One author has embodied the affect of these changes with the following comment:

Although everything in our daily lives seems much the same from one day to the next, changes under the surfaces of life's routines are occurring at almost unimaginable speeds. Nothing symbolizes these changes more richly or will be viewed by history more significantly than the computer. As a society, we are moving from the old to the new and are caught between a predominately industrialized era and a new emerging order. Amid the trials of the present, the restructuring of society proceeds unrelentingly, and the educational system will have to adjust to meet the needs of those who must function in the new information environment (Norton, 1983).

Computers have had a great impact on education in the past five years. An example of this impact is the tremendous growth of microcomputers in the traditional classroom. According to a 1982 survey by Market Data Retrieval (Petty, 1984), 58% of the classrooms in the nation's schools had at least one computer, a figure likely to increase. An immediate demand for the most modern and effectual methods of instruction has evolved as a result of the highly technological world we are creating. Society

has demanded that the school graduate students with marketable career skills so they can function in today's market place. Clements and Gullio (1984) state "this need is evidenced by the fact that today's high school graduates have a higher unemployment rate than any in the past, independent of the economic health of the country." The incorporation of microcomputers as instructional aids is one viable way educators are trying to meet these demands. However, the integration of microcomputers into the traditional classroom is no simple task, and validating studies have not kept pace with the actual uses of computers as aids to instruction. At times, educators have relied on CAI research or the evaluations of large CAI projects (Kearsley, Hunter, and Seidel, 1983) to justify the purchase of CAI in their school systems. However, there are major differences between past CAI research and studies and the current microcomputers which make such justifications unstable. Educators should be aware of the major differences since this new generation of microcomputers is saturating the classroom at an overwhelming pace.

According to Rawitsch (1982) in Minnesota, over 95% of the state's public colleges and school districts are using the computer in instruction. Richard Hooper's (1984) research on the Tennessee Computer Library Pilot indicated

that other states besides Minnesota have become active in applying the computer to educational problems. Among these are North Carolina, Pennsylvania, Florida, Montana, Virginia, New York, Texas, and Tennessee. Decreasing cost has made computer purchases by school systems a realistic option. This decrease has occurred because of the increased competition between manufacturers as well as advancing technology. This is evident when the Apple Computer Corporation offered to sell to the state of Tennessee 5,200 Apple IIe microcomputers for a mere \$733 each (King, 1984). Therefore, such reduced cost of equipment, along with new software and increased interest by the students, teachers, and professional education interest groups, has led to a proliferation of computer instruction.

The effectiveness of CAI has been heavily researched over the past 10-20 years. Thirty-two CAI studies were examined by Edwards et al. (1975) concerning different grade levels and subject areas. They discovered the following:

1. When CAI was provided with traditional instruction, this instruction was more effective than traditional instruction by itself.
2. When CAI was used in the place of traditional instruction, there was no apparent advantage for either CAI or traditional instruction.

3. When CAI was used in some studies, it was more effective than traditional instruction, but in other studies was no more effective than traditional instruction.

4. When CAI was used, less time was taken by students to learn (formulated from nine studies), although the retention may not have been so strong as if other traditional methods had been used.

5. When CAI is used, lower ability students may benefit more than average students.

More recent research published by computer oriented periodicals have agreed with these earlier findings (Bracey, 1982); Chambers and Sprecher, 1980; Thomas, 1982). To a great extent these findings report that CAI provided equal or better achievement in less time, along with encouraging a positive student reaction, especially with below average students.

Meta-analysis was applied by Kulik et al. (1983) to 51 evaluations of CAI in grades six through twelve. There was not a strong relationship between the design features and the findings. However, when CAI was compared with traditional instruction these results were noted:

1. The use of CAI raised final examination scores .32 standard deviations or from the 50th to the 63rd percentile, based on 48 studies.

2. CAI classes showed a retention of follow-up exams over the course of several months by .17 standard deviations, based on five studies.

3. CAI classes were more positive in attitude toward the subject matter, based on 18 studies, while less time was taken to learn by students in CAI classes, based on two studies.

However, these studies exhibited major differences in methodology from current approaches available with the use of microcomputers. Therefore, some of these previous findings are not reliable by today's standards. There are three probable reasons for this difference.

First, most of the previous CAI studies were only evaluating the computer as a piece of hardware being introduced into an educational setting. Kulik et al. (1983) found that the needs of the students being studied were being met by locally produced software. A combination of trained personnel along with special hardware and software were the independent variables of those past efforts. Only specifically trained educators were used to teach CAI, because the terminals used by the students were connected to large mainframes (Magidson, 1978). Today, almost any classroom teacher or aide can use CAI on microcomputers with commercially prepared software.

Second, most of these early experiments concerning CAI were made possible through federal funds, conceptual demonstrations or prototypes (Kearsley, Hunter, and Seidel, 1983). These are not the typical settings for CAI in traditional classrooms.

Finally, before microcomputers, CAI was given in labs specifically designed for computers (Chambers and Sprecher, 1980). However, today's CAI is generally given in classrooms attended by every student, complete with the distractions, noises, and events that occur in classrooms.

Statement of the Problem

This research assessed the effectiveness of computer assisted instruction implemented through the use of microcomputers within Chapter I* mathematics classes under as normal classroom conditions as possible. The instructional goal was to assist low achieving Chapter I students in grades 9 through 12 to attain mastery of certain basic skills in mathematics.

The following null hypothesis was tested at the .05 level of significance: There is no significant difference in the mean score, as measured by the Metropolitan

*See Definition of Terms.

Mathematics Instructional Test, between Chapter I students receiving traditional instruction (control group) and those receiving traditional instruction supplemented with computer assisted instruction (experimental group).

Procedures

The samples for this study were ninth, tenth, eleventh, and twelfth grade Chapter I students at Fulton High School (Knoxville City Schools, Tennessee). The students who were involved in the Chapter I program had failed to achieve 80% of grade level objectives on the Knoxville Basic Skills Test (grades 1-9), or failed to demonstrate proficiency on the State Proficiency Test (grades 10-12). The classes were randomly assigned to one of the two groups.

The design used in this study was a pretest-posttest control design. This design was chosen because it was essential to obtain a pretreatment measure in order to evaluate the effect of the treatment. The Metropolitan Mathematics Instructional Test, Form J, was administered as the pretest and posttest to both the experimental and control group.

A pretest was given to establish the initial level of the students' mathematical achievement. During the 13-week treatment, one group utilized computers in

math instruction and the other group did not. To control for variation in instruction, each group was taught by the same teacher and used the same textbooks, curriculum guide and other materials.

According to preset guidelines each student in the treatment group was scheduled to work on the computer at least twenty minutes per class. Schedules and time sheets were maintained in order to maximize compliance with established guidelines (see Appendix C).

Both the control and treatment groups were presented each day with the daily instructional objective. The teacher then went on to explain the concept to be learned that day. The control group worked practice problems from the textbook. The treatment group worked practice problems through the use of the computer.

At the end of the 13-week period, a posttest was given to both groups to determine the ending level of their achievement. The scores of the computer assisted instruction group and the noncomputer assisted instruction group were compared by using an Analysis of Covariance.

Assumptions

In this study, the following assumptions were made:

1. The Metropolitan Mathematics Instructional

Test, Form J, is an accurate instrument to measure math concepts covered in the study.

2. All phases of administering the experiment were carried out under uniform classroom conditions.

3. All treatment material was understood by all subjects.

4. Subjects responded honestly and to their best judgment during the study.

5. Giving the same test as a pretest and posttest is not considered to be a major threat to the external validity of the study because of the time factor.

6. The teacher who is in charge of all the classes was knowledgeable of the research design. This did not encourage him to increase or better facilitate his own instructional efforts.

Limitations

1. Design considerations did not determine the number of students in either experimental or control classes. The school administration and individual scheduling needs were the determining factors.

2. Computer assisted instruction time per student was influenced by individual absenteeism, competing school activities, as well as individual teaching decisions.

Delimitations

1. Each individual had unlimited access to a single computer unit. No sharing of computers occurred.
2. The use of commercial and noncommercial software was utilized in this study.

Definition of Terms

For the purposes of this study, the following terms were defined:

CAI. (Computer Assisted Instruction). Instructional material presented by a microcomputer with interaction between the student and computer.

Chapter I. A 1965 federal program which provides financial assistance to local school districts in planning and operating special programs for educationally deprived students. The basic goal of the Chapter I remedial program is to identify student academic deficiencies and provide an individualized program to meet the special educational needs of each child.

Computer Program. A complete set of instructions whose main purpose is to tell a computer how to do something. It contains all the necessary directions to fulfill its purpose.

Drill and Practice Programs. A program used to practice material already studied.

Experimental Group. A group in which the normal curriculum is supplemented with CAI.

Instructional Game. A program in which educational goals are achieved through competition and a score.

Microcomputer. (Sometimes referred to as a personal computer.) A general purpose computer of small size and low cost capable of processing or manipulating data, graphics or words. It has the ability to store and retrieve information. This includes the computer, a disk drive and monitor.

PLATO. (Program Logic for Automatic Teaching Operations.) A set of CAI programs created by Control Data Corporation available for microcomputers.

Simulation Program. A program that allows a student to create a real or imaginary situation.

TICCIT. (Time Shared Interactive Computer Controlled Information Television.) A set of CAI programs developed at the University of Texas and Brigham Young University which are stored on mainframe computers.

TIM. (Tennessee Instructional Model). A prescribed instructional lesson design used by teachers for their lesson planning.

Software. A computer program or a set of computer programs, stored on diskette usually including an instructional manual.

Traditional Instruction. Instructional material presented by a teacher, making use of textbooks, chalkboards, verbal discussion, and pencil and paper.

Tutorial. A program of instruction used to teach or reinforce new concepts with practice material.

Organization of the Study

The remaining four chapters of this study are organized in the following way:

Chapter II contains a review of literature relevant to the study. Chapter III describes the experimental design and procedures of the study. Chapter IV contains a presentation and analysis of the data collected in the study. Chapter V summarizes the experiment and presents conclusions and recommendations for further study.

CHAPTER II

REVIEW OF RELATED LITERATURE AND RESEARCH

The report of literature review will encompass four areas. Information pertaining to assets of computer assisted instruction in the classroom will be presented first. The second section will present a review of the educational learning strategies and theories associated with the role of computer assisted instruction. Views on effective and efficient software evaluation will comprise the third section. The last section will pertain to computer assisted modes such as tutorials, demonstrations, and simulations for use in classroom instruction.

Introduction

During the 1960s, there was little interaction between students in a given curriculum and computers. However, the curriculum that was using computers was mathematics. A few math teachers tested and utilized CAI on large timesharing computer terminals. Through their innovation and initiative the first large-scale CAI projects were in mathematics. These math projects were also instrumental in discovering the computer's vast potential for other areas in education (Kelman et al., 1983).

Now, with the advent of new computer technology and a new generation of software, a new computer age is dawning. The computer is becoming more than a tool for educators; it is becoming a part of the educational process. The computer is not the latest in audiovisual equipment but it is a device that has the potential to change what is being taught and the methods used to teach. With this in mind, it is up to the mathematics teachers who have been involved from the beginning of CAI to play a major role in finding and using that potential (Kelman et al., 1983).

Assets of Computer Assisted Instruction

Computer assisted instruction (CAI) is usually defined as instructional material presented by a computer with interaction between the student and computer. It can be said that modern-day CAI originated in the early 1960s on large mainframes. These mainframes were usually located at large universities. Most of the CAI programs used today on microcomputers in some way or another evolved from these mainframe programs (Kelman et al., 1983).

Contrary to many CAI experts, Lewis (1983) believed there was an abundance of quality educational programs stored at many of these institutions of higher learning which were not being utilized. Many of these systems were developed by PLATO of Control Data Corporation and by a

system called TICCIT authored by Brigham Young University (Judd, 1984). Using audio and visual means these programs provided the teacher with a delivery system that employed many CAI modes such as tutorial, drill and practice, and simulation (Splittgerber, 1979).

PLATO was a teacher-centered instructional approach system. In this approach the teacher had full control of the program with such things as pacing, grading, and scheduling (Bunderson, 1981). The PLATO system had two primary goals. They were:

1. Create computer hardware and software specifically for educational purposes.
2. Develop a system as cheaply as possible which could instruct as many learners as possible on a wide range of subjects (Dennis, 1984).

PLATO is still used today in the United States and several other countries by people of all ages with different learning abilities and goals. It is also used to reach individuals with special needs and physical disabilities such as blindness (Dennis, 1984).

TICCIT was different from other programs at the time because it combined components from existing systems and designed another unique system specifically for educational instructional application (Hofmeister, 1984).

TICCIT was a student-centered instructional approach system. With the use of this student-oriented approach, the machine, the books and the teacher served as a guidance resource for the student (Bunderson, 1981). This program was largely based on instructional theorems and hypotheses in the area of concepts and learning. Rules, examples, practice and help were the main components of this program (Bunderson, 1981). Because of the influence of these main-frame programs and the technological advancement of micro-computers, there has been a resurgence of CAI in the field of education.

Why this CAI resurgence? Magidson (1978) claimed that research has shown that there are many educational assets to be gained by CAI not possible with traditional instruction. He lists five such assets:

1. CAI simulates experiences and has the ability to personalize as well as individualize instructional processes.

2. CAI encourages students to become active in their learning while it serves as tutor, text and test.

3. CAI prevents students from going to more advanced levels until they have shown mastery, as well as letting them work at their own pace.

4. CAI provides summaries of achievement and immediate feedback and keeps the students informed on their progress.

5. CAI allows students to review previous instruction, ask for help, or go on to enrichment activities, thus giving them a control over their learning.

Bunderson (1981) reported that in the last twenty years research has shown that CAI can be used as a strategy to achieve three basic educational objectives:

1. Memory of simple skills;
2. Concepts and rule learning;
3. Integration of skills and integration of skills and concepts.

The memory of simple skills deals with the stimulus-response procedure. A term is presented and then the term is given again as a response through recall and recognition. The concept and rule learning objective involves the application of a procedural rule to a certain situation. The integration of skills objective involves the selection and integration of a number of concepts and rules involving a certain case.

Herriott (1982) claimed that CAI can:

1. Provide one-to-one information with a generally high rate of success;
2. Provide for instruction and material within the program that is not evident to the student, such as remedial or enrichment instruction;

3. Allow the student to progress at the best rate for him/her, while keeping track of his/her progress as needed;

4. By direct display, supply information retrieval, provide support by means of audio and visual devices linked to the computer, and can also refer students to sources for other mediums.

Holmes (1982) stated:

The computer can provide mainline instruction and in so doing supplant, in whole or in part, traditional modes of instruction; such as the book or teacher. The computer is quite able to provide the learner with information via a straightforward presentation of data, or a tutorial approach in which the student is tested on his/her comprehension as the program progresses.

Clements and Gullo (1984) listed four positive characteristics of CAI.

1. CAI provides alternative series of sequenced experiences as well as different paths for students to explore.

2. CAI offers individualistic independent pacing.

3. CAI provides controlled, relevant, immediate reinforcement.

4. CAI provides a degree of mastery by evaluating a student's performance accurately and swiftly.

Spitler and Corgan (1979) claimed that CAI can provide innumerable benefits for teacher and learner. They state, "The slow or remedial student can have a tutorial aid available which can provide the individual assistance needed; the bright student who clearly needs some higher-level work is provided challenges; and the teacher has a test monitor which provides tests at proper intervals."

The key to effectively utilizing the assets of CAI toward meeting the needs of our education system is the teachers. Their lack of education or interest in the field of CAI guarantees failure.

Learning Theories and Strategies Associated with Computer Assisted Instruction

Because of the American educational philosophy, "Excellence for All," schools have been mandated to provide courses, activities and responses that prepare students to meet the demands of society (Gwyn and Chase, 1969). As society changes, so do the demands of the educational system. Striving for this excellence has caused a lot of controversy, confusion, and debate. Most of this conflict has been between the school and educational theory (Gwyn and Chase, 1969). The greatest conflict between strategies and theory in the last ten years has been concerned with CAI. When developing and

designing any CAI program, a variety of educational strategies and learning theories should be understood. Even though CAI is not new, only recently, through the advent of the microcomputer, has its use been made feasible for all schools to take advantage of and utilize this learning tool.

Gagne et al. (1981) stated, "One of the first steps in designing CAI, so as to take advantage of principles of learning derived from theory and research, is to categorize the type of learning outcome." They explained that this is done in two ways:

1. Examining the target of a lesson;
2. Identifying what type of performance is expected of the learner after he or she has learned (learner outcomes).

Gagne et al. (1981) also described five learning outcomes that have been researched which are most likely to be aimed for CAI instruction. They are:

1. Verbal Information. This consists of meaningful knowledge, which recalled as words and sentences, includes names, labels, and organized bodies of semantically related propositions. These are found in both oral and printed connected discourse.

2. Defined Concept. This consists of concepts that can be identified by showing or telling the rule that defines them.

3. Concrete Concept. When a learner has acquired a concrete concept, he has learned to identify instances of an object's property, such as "round," of an object, such as "ceiling," of an event, such as "turning," or of a spatial direction, such as "up."

4. Rule. Learners have acquired a rule when they can demonstrate application to one or more instances which were previously unencountered.

5. Problem Solving. When a learner can solve a nonroutine problem with previously learned rules, he has acquired problem solving.

Once the learning outcome has been identified it is necessary for the CAI designer to develop a program which will stimulate learning to achieve these outcomes. Wade (1981) explained that research of learning theory has indicated that there are nine internal processes of learning which stimulate these learning outcomes, and nine external instructional events which may be used to support the internal process of learning. An author should keep these events in mind when creating a CAI program. The processes of learning are:

1. Alertness
2. Expectancy
3. Retrieval to working memory
4. Selective perception

5. Semantic encoding
6. Retrieval and responding
7. Reinforcement
8. Cueing retrieval
9. Generalizing

The events are:

1. Gaining attention
2. Inform learner of lesson objective
3. Stimulating recall of prior learning
4. Presenting stimuli with distinctive features
5. Guiding learning
6. Eliciting performance
7. Providing information feedback
8. Assessing performance
9. Enhancing retention and learning transfer

It should be noted that these nine events of instruction are related to the cognitive process. Gagne et al. (1981) pointed out that it is important that designers of CAI take into consideration all nine events. Too often, designers consider only questions and feedback.

Wade (1980) discussed information holding functions of the human cognitive process which CAI developers should be conscious of:

Newland and Simons have described three information holding functions of the human cognitive process. Outside information is sensed and held for about a second in visual, auditory, or tactile

(touch) registers while being formed in a short-term memory. The short-term memory may hold information for half a minute or so while being coded for storage in the long-term memory or while being considered or used to activate the output.

Three instructional implications which should be understood when developing any CAI program have been described by Hestenes (1979), which were taken from Newland and Simons' information holding functions.

1. Short-term memory should not be overloaded; it can hold one piece of information at a time, and a certain amount of time is required for coding, which allows permanent storage.

2. Information is retrieved and processed slowly from the long-term memory, therefore, more time than what is normally allowed is required for thoughtful responses.

3. Good control of the short-term memory is important in communicating and learning; such control is achieved by writing, rehearsing, and other similar activities.

Schwartz (1984) believed strategies associated with the role of computers is very important. He believed that one must not assume that theories and strategies are not predetermined by the computer itself. Because of the importance of the technologies and strategies, theoretical approaches of education must be examined before introducing microcomputers in the classroom.

Schwartz also claimed that the attractiveness of technology should not influence teaching roles and strategies. Instead, they should be influenced by the teacher's developmental and learning views. Curriculum materials are influenced by two criteria:

1. Current goals and teaching styles;
2. The perceived level of the child's development and learning.

Schwartz (1984) stated:

As the technology for processing, organizing, storing and retrieving knowledge becomes increasingly available to the general population, it is projected that teachers can no longer command the primary position as a primary source of knowledge. From this perspective, the role of the teacher will inevitably change from being a key knowledge source to being a knowledge resource manager and an agent for socializing the young in the school setting.

Three common approaches to child development and learning which have been studied extensively are:

1. Behaviorist approach;
2. Cognitive-developmental approach;
3. Psychosocial approach (Schwartz, 1984).

The teaching strategies usually associated with the behaviorist approach are:

1. The teacher is the manager of the learning environment.
2. The teacher schedules the learning task.
3. The teacher reinforces and implements the teaching plans (Schwartz, 1984).

Theoretically, when using a tutor program the teaching roles and strategies remain the same. The computer becomes a medium for transmitting knowledge, monitoring skill practice and providing reinforcement. When using the computer the teacher still continues to plan the student's experiences, while giving presentation of data and the arrangement of practice to the software. When using the appropriate software, the teacher, with a computer, can become a very effective behaviorist (Schwartz, 1984).

Schwartz (1984) listed three common teaching strategies associated with the cognitive-developmental view. They are:

1. The selection of materials which students manipulate, act on, and thereby construct understandings of the relationship between objects, actions and events;
2. Observations of student's interactions to identify points of entry for teaching;
3. Entry into the student's world to extend exploration and experimentation within the context of the on-going actions of the student.

Schwartz (1984) explained that when a teacher is entering the child's world, he/she should focus on helping the child to identify the intent of his/her actions. Schwartz lists five typical questions which can be asked to achieve this strategy:

1. What are you trying to make happen?

2. How did you make it happen?
3. How else can you make it happen?
4. Which way is better, and why?
5. What do you think will happen now?

By looking at these strategies and principles one can conclude that the main objectives of the cognitive-developmental teacher is to facilitate transfer of learning through exploration and experimentation.

The microcomputer is an excellent vehicle for cognitive educators to use in order to meet their program goals. The simulation program is a three-dimensional package that offers the students the opportunity to learn through interaction. This program conforms with the cognitive-developmental view that the relationship between actions and events are important while fostering information seeking skills through trial and error (Schwartz, 1984).

Micro-Worlds is also a program which adapts to the cognitive-developmental strategies. This includes the view that the child must be internally motivated and have control of events which facilitate learning. Micro-Worlds' programs can easily be adapted to the individual's needs (Schwartz, 1984).

The psychosocial view (humanist) emphasizes the idea of human interaction for personal as well as educational

development. The humanist places much emphasis on self-awareness and awareness of others when approaching teaching roles and strategies. This is done by a variety of interactions between students and adults, meeting to deal with the trials and other aspects of living, working, and growing together. Schwartz (1984) stated:

Through language and action, the teacher focuses attention on common characteristics, in humans' needs for trust, respect, belonging, autonomy, and human patterns of responding to success, failure, threat, joy and sorrow, and individual differences in learning style, interests and abilities.

Many educators believe that the computer is the antithesis of this type of teaching principle. However, research has shown that students use the computer as any other teaching device, manipulating and learning through it. It is shown that because the computer is "rigid" that students actually interact with their teacher and peers more often than they would with other more fluid devices. With this type of tool they need information, instruction, encouragement, and the appreciation of accomplishment. All these aspects encourage humanistic strategies related to the psychosocial (Schwartz, 1984). Schwartz (1984) believed that teaching roles and strategies used with learners using microcomputers will reflect the teacher's professional views and values.

Courseware Modes

Drill and Practice

CAI has many courseware modes (styles). One such mode is the drill and practice program. Bunderson (1981) claimed the drill and practice programs are very widespread and successful among courseware packages because they have had great success in proving the general concept that providing students work with feedback can produce gains in performance. (However, research had shown that students using drill and practice show no gain in conceptional understanding.) When using these programs it is not essential for the teacher to be completely involved.

Swartz et al. (1984) listed five advantages of drill and practice:

1. Drill and practice allows for individual instruction.
2. Drill and practice allows the teacher to use human sensitivity in crucial areas where it is needed.
3. Drill and practice provides unlimited supply of randomly selected practice programs.
4. Drill and practice provides automatic scoring and immediate feedback to students who are practicing.
5. Drill and practice engages and motivates students to do repetitive tasks they would usually be bored with.

Coburn et al. (1982) explained how drill and practice programs work. First they usually ask students where they would like to begin. The program then prints a problem or a group of problems on the computer. The students then respond by typing the answer on the screen. If the answer is correct the computer presents another problem. If not, the student is directed to try the problem again. Automatically the computer records the number of right or wrong answers.

Kelman et al. (1982) maintained that drill and practice programs take the drudgery out of pen and pencil drills. The teacher can actually choose the level in which he/she wants the student to begin. But it must be kept in mind that drill and practice can be tedious or dull and may sometimes reinforce incorrect learning.

Hofmeister (1984) lists three important uses of drill and practice.

1. Drill and practice programs can be used for subject matter that needs to be well mastered and to facilitate the effective performance at higher skills.
2. Drill and practice programs can be used after the concepts related to the skill have been taught.
3. Drill and practice programs can be used just prior to the applications of these skills to develop higher skills in the curriculum hierarchy.

Hofmeister (1984) continued by explaining that drill and practice are the most used and criticized of CAI programs. When the computer "craze" began, most of the programmers began their careers on the drill and practice programs because these packages did not require sophisticated skills. The result was a flood on the market of poorly written programs that confused the learner and embarrassed the authors. In Hofmeister's opinion much of the criticism is unfounded. Many educators fault drill and practice programs but many times the problem is with teacher management. This program is used many times as an alternative for teaching underlying concepts with no meaningful follow-up skills.

According to Magidson (1978), drill and practice is widespread because it is an excellent tool for freeing teachers from the monotonous job of making up problems and checking them. This type of program usually gives a sequence of questions for the learners to answer and gives some feedback on the questions. Unless the learners show mastery they will not be allowed to continue to a more difficult level.

Hofmeister (1984) believed that users of drill and practice programs must keep in mind that these packages are based on the stimulus-response type of instruction. These programs do not facilitate higher cognitive skills

but they do develop preliminary skills that must be automatic. Also drill and practice programs are not sensitive to students. There are programs on the market that give off loud sounds when a mistake is made. This naturally could cause problems since it advertises the student who is experiencing learning problems.

Tutorials

Another common and popular mode is the tutorial. Popular Computing (1984) describes tutorials as programs that give students a certain body of knowledge and then asks for certain responses. If the student does not give acceptable answers the program reacts by giving directions.

Hofmeister (1984) explained that a tutorial is different from drill and practice in the fact that the tutorials introduce a concept. The tutorial program introduces a subject in text form. He lists three instructional design principles of tutorials.

1. Tutorials should actively build on student response.
2. Tutorials should use field testing and program revision to bring student errors to a minimum.
3. Tutorials should provide the knowledge of the results to students in some form.

He also listed three ways in which tutorials teach:

1. A concept or rule is introduced and described.

2. Examples are provided for.
3. Applications or rules or concepts are provided.

In certain points on the program the material is usually reviewed and additional practice is given.

Riedesel (1985) maintained that tutorials are excellent tools to use when learning a new concept. However, when a teacher uses a tutorial, a variety of teaching strategies is required. He continues by giving three suggestions to anyone purchasing a tutorial program: (1) make sure the topic is one which you want to develop; (2) make sure the tutorial effectively handles logical errors; (3) make sure the tutorial makes use of the unique capabilities of the computer, such as moving the user along rapidly when understanding is evident, keeping track of errors and branching on the basis of errors.

Coburn et al. (1982) described how a tutorial explains to the student some area of knowledge. When the student types in a response the computer responds in some manner and asks more questions. Coburn et al. stated, "Most tutorials programs resemble Socratic dialogues in which the computer presents some information about which it then asks a series of questions, each with a fairly limited range of possible responses." They believe, however, that tutorials at times can limit pedagogy by manipulation of the student's responses. But at the same time tutorials are excellent for students who

have missed an assignment and need to catch up quickly. With tutorials, students can continue at their own rate and interact one to one with each question, something that cannot be accomplished in a traditional classroom.

Bunderson (1981) emphasized tutorials as a strategy used when dealing with the teaching of a concept and rule. He explains that this is a branching strategy which includes constructed responses. Simply, the tutorial could be described as a rule-example-practice strategy. Bunderson continues by explaining that the tutorial programs include rules, definition of concepts or statements of principles. When the learner uses the program, examples are given applying the rules and concepts, and then practice is given with the learner controlling the selections. In order to help the learner select wisely, the program contains an advisor program that aids the learner.

Simulation

Another common CAI mode is the simulation program. Popular Computing (1984) described simulation as a program that allows students to create a real or imaginary situation. The program then allows the student to manipulate a situation by feeding the computer facts. The learner then can observe and alter the consequences of the choice.

Hofmeister (1984) described a simulation as a program that recreates an event. He features two main components of simulations. First, there should be an operational model. The model will react or operate in a predetermined manner when an element or elements are changed. Secondly, a real activity should form the pattern for these reactions. Hofmeister continues by claiming that simulation can make valuable contributions to educate in the following ways:

1. Can be used where it would be impossible or difficult to use a conventional experiment;
2. Can be used where laboratory and experimental apparatus is either too expensive, complicated, or not available;
3. Can be used where suffering or dangerous experimental situations could occur;
4. Can be used where an unacceptably long time would be needed for a conventional experiment.

Swartz et al. (1984) described simulation as a "slice of reality." With simulations students can test a hypothesis and see the consequences of their choices. By using simulations the student can learn by doing. Swartz et al. list two main advantages of simulations as educational programs. These advantages are:

1. They can compress time, modeling in a few minutes events that might take much longer in the real world.

2. They can bring into the classroom experiences that would be unavailable to classroom-bound students without the computer.

Swartz et al. (1984) do maintain that simulations have their drawbacks. When using simulations students are indulging in a fantasy world. Secondly, the variables in the simulation could be so numerous and complex they would simply fluster and bewilder the student.

Coburn et al. (1982) believed that simulations are excellent learning tools because they let students examine situations and events that they would otherwise never be able to experience due to danger or lack of time. Simulations can also be used to promote problem solving skills, mastery of content, concept development and for simply motivating purposes. Coburn et al. (1982) emphasized one must be aware that simulation can many times lose its power of explanation and description and at the same time be so complex that students cannot manage the variables. It is also important that when instructors use simulations it should be accurate. That is, if it is an example of a science experiment, the results should be the same as the actual experiment.

A type of simulation that is becoming very popular with educators is the Microworld package. These are simulation packages that create make believe educational environments. "Mathmagicland" or "Musicland" could be

examples of these types of programs. Proponents see a bright future for these types of programs in CAI (Swartz et al., 1984).

Demonstration

A demonstration package is still another common CAI mode. Coburn et al. (1982) discussed how demonstration packages are used in education under many situations, usually to help the instructor in the primary instruction of students and as a method of reviewing material. By using these packages with color graphics and sound effects instead of the blackboard or an overhead projector, they can be an effective way as well as an appealing manner of emphasizing certain goals and objectives.

It should be mentioned that demonstration packages can be expensive, and take an exorbitant amount of instructor preparation and have a tendency not to work at an inconvenient time. However, they may be a very powerful attention device and can be used very effectively and efficiently by a young, inexperienced and clumsy science teacher (Coburn et al., 1982).

Kelman et al. (1983) discussed the many attributes of demonstration packages. It is a dustless chalkboard which is neat, organized and very fast. The graphics along with the animation capabilities and possibilities are enormous. When using other methods of demonstration (overheads,

projectors, chalkboards) some artistic ability is needed along with hours of preparation. On the other hand, the computer can create a colorful, clear, and precise display very quickly. Even abstract concepts when explained through graphics would take new meaning. The teacher can also use the demonstration to organize data collected in any subject area and display them graphically. One of the most important aspects of the program is when students become involved in running the demonstration. When this happens, the programs become a significant learning device.

Kelman et al. (1983) emphasized that there are some disadvantages of demonstration programs. Setting up multiple screens for a large audience can be inconvenient and the equipment may falter at an unfortunate time. Also the program may not demonstrate because of some unexpected response by the student. One must also realize that in order to develop some demonstration packages, too much time and effort may be required and commercial packages may not be worth the expense. Furthermore, packages which show no interaction with the students and require limited response fail to take advantage of the worthwhile capabilities of the demonstration packages.

Instructional Games

Another excellent CAI program is the instructional game. Coburn et al. (1982) explained that these games are

similar to the arcade games only in that there is competition and a score is kept. The motivational factor of this package is very beneficial when used to foster educational goals. The games may be used as a break between classes, tests or when students have finished their assigned work. The package can also be used as the main source of instruction which may take days.

Dennis and Kansky (1984) list six positive attributes of instructional games. They are:

1. That a player's success is clearly related to his/her own actions;
2. That the teacher becomes more of a partner and less of a judge;
3. That relevant goals for classroom instruction are provided;
4. That students are able to see what will be important to their future lives by engaging roles;
5. That such education will promote positive attitudes from students;
6. That instructional variety is provided.

Kelman et al. (1983) believed that regardless of your attitude toward computer games, the potential educational attributes should be recognized. Once a learner begins the game a fantasy world is created in which the player has control, in spite of a changing environment. The games can

also be a fast paced way to test different motor and cognitive skills. Another positive feature of the program is the ability of the teacher to vary the speed of the game to the capability of the learner. Kelman et al. (1983) added that Dr. Thomas Malone's research had identified three characteristics of computer games which make them intrinsically motivating. They are:

1. Challenge;
2. Fantasy;
3. Curiosity.

Denenberg (1982) claimed that opponents of the computer games argue that players are acquiring skills and knowledge that can be used only for a specific game.

Denenberg maintained that the player is actually learning a problem solving skill and the acquisition of this skill is an important educational process. The problem solving experience can be transferred to other learning situations. Denenberg (1982) listed two aspects of computer games that are appealing to many educators. They are:

1. Creativity;
2. Control.

He explains these aspects by stating that the player can lose himself in the activity. Time seems to stop. The player is constrained by rules and regulations but finds himself in full control of the situation. The games can increase or diminish the player's ego. Because computer

games can be incorporated into CAI, Denenberg believed it would be useful for educators to better understand computer games.

Software Evaluation

As one evaluates the different CAI programs, it becomes evident that it will never replace the teacher. In order for CAI to be effective the teacher must have the normal understanding of curriculum and the instructional skills that are required by all teachers. How well CAI meets the needs of the students and teachers depends on the quality of the CAI product and how efficient the teacher is in integrating CAI with on-going traditional instructional programs. Hofmeister (1984) believed that proper CAI can be inadequate if used at the wrong time in the instructional process of introduction of concepts and could lead to a lack of classroom competency.

Bramble and Mason (1985) claimed that computer instructional software is an educator's tool, and with the right tool a teacher will do a better job in the classroom. Most teachers are experienced in knowing what to look for in selecting tools (textbooks, worksheets, films, and laboratory kits) to fit instructional daily needs. But with the advent of new technologies such as instructional software, teachers may not have the experience to distinguish between good or bad software.

One must realize that computers will not automatically facilitate learning in the classroom. Before using, teachers must take into consideration what is to be accomplished in the curriculum. When these needs have been identified the software should then be chosen. One must remember never to randomly buy the software and then manipulate it to meet his/her needs (Bramble and Mason, 1985).

Bramble and Mason (1985) explained that developers of MicroSIFT Evaluation Forms suggest that software can be judged on the basis of three characteristics.

1. Content. The software should meet the needs of the curriculum and be free from racial, sexual or ethnic biases.

2. Instruction. The purpose of the package should be appropriate for the students as well as motivational and stimulating.

3. Technology. Effective and comprehensive supporting materials should be available along with the software. The students should be able to work independently when using the software, and the computer's capabilities (graphics, sound) should be utilized.

Bramble and Mason (1985) listed four ways to gain information about the quality and capability of the software without investing a great deal of time and energy. They are:

1. Using the knowledge of colleagues and others who are familiar about software;

2. Using evaluations that have been prepared by others;

3. Using the software vendor's presented information;

4. Using simple common sense.

Kennedy (1984) described an evaluation form developed by the Northwest Regional Education Laboratory. This list simply gives one a general comprehensive view of the important features and characteristics that sound software programs should have. The features are:

1. The text should contain no errors.

2. The value of the test should be educationally sound.

3. The text should be free of prejudice toward a particular group, race, or religion.

4. The software packages should succeed in its intention.

5. The text should be free from inconsistencies (clear and logical).

6. The text should not be above the students.

7. The graphics, color, and sound should be suited to the instructional purpose.

8. The software should be encouraging.

9. Creativity should be encouraged by the software.
10. Feedback is efficiently and effectively used concerning the learner's responses.
11. The learner should be in control of the program and progress at his/her rate.
12. The student's past experiences should be built upon by the lesson.
13. The software can be dependable during normal use.
14. The software can be easily used by the instructor.
15. The displays are adequate and create the desired effect.
16. The programs should not be above the learner's computer capabilities.
17. The student's support materials should cover a wide scope and be efficient.

Coburn et al. (1982) believed since the key component of CAI is the program, competent evaluation of the software is essential. Guidelines for evaluation of software resembles the same criteria for choosing traditional educational materials such as textbooks or audiovisual materials. New criteria need to be developed when evaluating program packages because of the great potential of the computer as an instructional medium. Coburn et al. maintained that using

the same standards of evaluation for computer programs and textbooks is not feasible because the form and function of some of the learning that is taking place is unknown. In Coburn et al.'s opinion the search for education software is and must be full of compromises. There is nothing wrong with this as long as the program package fits the needs of the instructor and learner.

Coburn et al. (1982) defined guidelines for evaluation into four areas of concern. They are:

1. PROGRAM CONTENT

- Is the material of suitable content for the learners?

- Are the curricular goals fitted by the content of the material?

- Are values expressed, and if so, what values?

- Is there an educational significance in the content?

- Have the goals of the materials been explained and are the objectives clear?

2. PEDAGOGY

- The program offers what nature of feedback?

- Upon what assumptions concerning learning and the process of how children learn is the software based?

- Is teacher intervention necessary or required, or is the package self-contained?
- Will different types of class arrangements be possible to use?
- Are learning modes of different varieties used?

3. PROGRAM OPERATIONS

- Is the program free from breaks or bugs?
- How are user errors handled?
- Does the user have any degree of control over the program operation?
- Does the program present clear directions?
- Is the documentation clear for the teacher as well as the student?
- Are graphics and sound, as well as color capabilities, used well?
- Are the screen displays effective?

4. STUDENT OUTCOMES

- How easy will students find the program to use?
- Will the program interest students?
- Are computer resources used appropriately?
- Are students learning what the program is intending to teach?
- Does unintended learning occur from using the program, and if so, what?

--Is this program as effective as noncomputer instruction within the same area?

Swartz et al. (1984) emphasized that the evaluation of software is not an easy process. If the software programs are being evaluated for a certain class, usually the teacher is the judge. The teacher must take into consideration the individuals involved and other variables that only the teacher can be conscious of. If the software is for district or county use, a committee should be the judge. But once you have a judge what procedure do you use? Swartz et al. (1984) described three steps that can help. They are:

Step 1

1. Scrutinize the printed material that arrives with the program.
2. See if the software runs on your computer.
 - Find out the educational objectives as well as who the software is intending to serve.
 - Learn how the software operates.

Step 2

--Ask yourself: Is the software following its intended educational practices and purposes? Is the software encouraging student participation with the computer? What amount of guidance will students require?

Step 3

- Review the software: answering as a student might, deliberately giving wrong answers, and examining the content as you go along.

Popular Computing (1984) discussed three areas which are important when critiquing software. They are design factors, academic content, and hidden biases and other tangibles. Some questions that should be asked are:

Design Factors

- Does the program hold student interest?
- Does it allow students to have fun immediately, or do they have to go through lengthy instructions first?
- Are open-ended responses called for more often than "yes" or "no" answers?

Academic Content

- Are problem solving skills developed?
- Are reminders and encouraging statements made when students make mistakes?
- Is creative thinking being stimulated?

Hidden Biases and Other Tangibles

- Does the program appeal to both sexes?
- Is it free from demeaning stereotypes and discrimination against women and minorities?

--Are violence and destructive humor avoided in the program?

Cohen (1983) believed with the number of software that has proliferated the market in the last five years, educators should purchase only quality software which can be utilized to produce higher student achievement. By pursuing only quality software, educators can force software publishers to create top grade programs. Cohen (1983) maintained that one can judge effective instructional programs by simply reviewing research. Research has shown that for all instructional materials (including micro-computer software) to be effective, they should have the following characteristics:

1. Give the objectives or purpose of the lesson in the material;
2. Scope and sequence of material, the systematic arrangement of the material;
3. Methodology or the mode of instruction of the material;
4. Evaluation, some type of feedback on the accomplishment of the learner pertaining to the objective (Cohen, 1983).

Cohen (1983) believed an educator should be able to evaluate whether or not a program is tightly designed by determining how these four constructs are being utilized. Cohen listed six generic (nonspecific) questions that can

be asked about computer software which pertain to the four constructs. They are:

1. Has a target audience been specified?
2. Are learner's entry competencies as well as rationale, goals and objectives specified?
3. Is the range and scope of content adequate to achieve the program's intent, while including higher-order objectives?
4. Is the instructional approach used for concept learning?
5. Have the instructions been stated clearly, is the instructional test formatted for easy reading, and is the vocabulary appropriate?
6. Are evaluation components provided (Cohen, 1983)?

Cohen (1983) continued with specific questions that need to be considered when evaluating the attributes of the microcomputer alone. These questions help determine utilization of the fullest capabilities of the microcomputer.

CURRICULAR CONCERNS

1. How is the program used in the curriculum?
 - As adjunct or supplementary to classroom teaching?
 - As mainline or basic?
 - Management purposes only?

--For other applications-diagnostic testing;
developing a course?

2. What mode of interaction is employed?

--Simulation?

--Tutorial?

--Game?

--Drill and practice?

--Problem solving?

USER SUPPORT

3. In what way is the student sequenced through
the content? Can teacher or student vary the content?

4. Has the instructional text been formatted for
screen display?

5. Are graphics used?

6. Are prompts and/or cues utilized?

7. Is the action on the screen?

8. How much user control is given to the learner?

9. Is the program's instruction computer-managed?

10. Is feedback used appropriately?

--Does it explain or inform?

--Is it immediate?

--Is it nonthreatening?

--Does it remediate?

--Is it relevant?

11. Are records stored for future retrieval on a
magnetic device?

TECHNICAL SOUNDNESS

12. Can the program be altered by teacher and/or student by reprogramming?
13. Is random generation used?
14. Are the component parts packaged correctly?
15. Are proper manuals provided?
16. Is it designed for quick loading and response time?

Cohen et al. concluded by explaining that combining these generic and specific questions, one can look at the attributes necessary to consider it in the design and evaluation of software. These questions could help an educator assess the overall quality of a software program.

Educators must realize that a well-written CAI program results from the primary goal of having the student learn. Teachers who do not sufficiently evaluate their software and use poorly written programs may cause apprehensions toward the computer, boredom with the subject matter, and most of all a resistance to further educational innovations (Spitler and Corgan, 1979).

CHAPTER III

EXPERIMENTAL DESIGN AND METHODOLOGY

Introduction

The experimental design and methodology are presented in several parts. This chapter describes the school and community, subjects, treatments, procedures, instruments, design, and statistical analysis of the experiment.

School and Community

This study was conducted at Fulton High School, located in the northern part of Knoxville, Tennessee, and is a part of the Knoxville City School System. The Southern Association of Colleges and Schools (1981) describes Fulton High School as a school that serves a middle- to lower-middle economic community. The community is relatively stable and most of the graduating seniors have attended Fulton for at least three years. Enrollment at Fulton High School is approximately 900 students with around 80% white and 20% black. Findings from the Southern Association of Colleges and Schools (1981) reveal that approximately 50% of the students who drop out of Fulton do so because of a lack of interest in school work. This

dropout rate is due in part to the large geographical area that Fulton serves. The other 50% drop because of withdrawal to other schools, illness, and pregnancies. Three areas of strength concerning Fulton High School are:

1. The school community is relatively stable.
2. The experienced core of teachers provide stability and experience for the students and newer teachers.
3. There is good rapport between the counseling staff, teachers and students.

Subjects

The subjects for this study were Chapter I students from grades 9, 10, 11, and 12 at Fulton High School (Knoxville City Schools, Knoxville, Tennessee). Each Chapter I class contained from 9 to 20 students. The students who are involved in the Chapter I program have failed to achieve 80% of grade level objectives on the Knoxville Basic Skills Test (grades 1-9), or have failed to demonstrate proficiency on the State Proficiency Test (grades 10-12). The students in the study participated voluntarily and consent forms were signed by both the participants and their parents (see Appendix A for copies of consent forms). It was explained to the students both orally and on the consent forms that their decision to participate or not to participate would not affect their course grade. All students chose to participate.

The Chapter I program was initiated in the high school because of the requirement that secondary students must pass the state proficiency test before receiving a diploma. The Chapter I program has two major goals:

1. The student's educational needs are to be met.
2. Mastery of basic academic skill is to be emphasized. Problem solving, understanding mathematical concepts and increased computational skills are the main components of the math program.

Treatments

At Fulton High School all math Chapter I students were taught by the same teacher. To facilitate normal day-to-day educational practice and the desirable research design of this study, certain compromises were made within the context of the project. One such compromise was the assignment of the number of students to the control or experimental group. This determination was by necessity made by the school administrators and the individual scheduling needs of each student.

The Chapter I students were divided into five classes by school administrators. The classes were randomly selected as control or experimental groups. The results were:

1. Class I. Treatment Group (Computer Usage), N=8.
2. Class II. Control Group (Noncomputer Usage),
N=15.
3. Class III. Control Group (Noncomputer Usage),
N=17. ✓
4. Class IV. Control Group (Noncomputer Usage),
N=13.
5. Class V. Treatment Group (Computer Usage),
N=13.

Procedures

The teacher involved in the study taught both the control and experimental groups. He has had more than 11 years of teaching experience in the secondary schools. All classes were taught within the guidelines of the Tennessee Instructional Model (see Appendix B). The format of this model includes the following:

1. Long Range Objectives/Unit Goal;
2. Instructional Objectives;
3. Set;
4. Instruction;
5. Closure;
6. Options;
7. Reminders;
8. Self-Evaluation.

All Chapter I classes have a professional aide. Responsibilities of these aides include required Chapter I administrative duties, grading papers, assisting absentees with make-up work, and aiding with enrichment and remedial instruction as needed. In all cases specific instructions are given by the teacher. The aides involved in this study stayed within the limits of the study.

The classroom curriculum for the control and experimental groups was the same except for the use of the computers. Enrichment activities and verbal reinforcement were experienced by both groups. All five classes used the same textbook and the same Chapter I curriculum guide.

Every student in the sample took the Metropolitan Mathematics Instructional Test, Form J. Scores were recorded and filed. The treatment group had use of eleven Apple IIe, three TRS-80 Model IV, and three TRS-80 Model III microcomputers throughout the 13-week study. The experimental groups were given a one-hour instructional class on the proper care and use of the computer. At all times during the study each individual had the use of one computer. At the end of the school year, the Metropolitan Mathematics Instructional Test, Form J, was again administered in an identical manner to both the control and experimental groups. The results again were tabulated and recorded.

According to preset guidelines each student in the treatment group was scheduled to work on the computer at least twenty minutes per class. Schedules and time sheets were maintained in order to maximize compliance with the established guidelines (see Appendix C). The experimental group used the computers for:

1. Fractions

- a. fractions and mixed numerals;
- b. lowest terms;
- c. addition and subtraction like fractions;
- d. writing like fractions;
- e. adding and subtraction unlike fractions;
- f. subtraction of mixed numerals;
- g. multiplication of mixed numerals;
- h. division fractions;
- i. division of mixed numerals.

2. Percent

- a. identify percents and decimals;
- b. writing fractions for percents;
- c. writing percents for fractions;
- d. finding the percent of a number;
- e. finding interest;
- f. finding what percent of a number is another;
- g. percent of increase and decrease;
- h. find a number given a percent;
- i. finding ratios and proportion.

Both the control and treatment groups were presented each day with the daily instructional objective. The teacher then went on to explain the concept to be learned that day. The time spent on the lecture is reflected on the schedule as "time on lecture." After the lecture, a different procedure was then followed, depending on whether the class involved was a control group or whether it was a treatment group.

The control group worked practice problems from the textbook. The time they spent on this work is reflected on the schedule as "independent practice." The treatment group worked practice problems through the use of the computer. Computer software was of the drill and practice type, to complement the concept taught by the teacher. The time these students spent working on the computer is referred to on the schedule as "time on computer."

Software Description

The experimental treatment in this study consisted of supplementary CAI in mathematics with the use of both commercial and noncommercial software. No one software program dominated the experimental treatment. The commercial software was identified and evaluated in the fall of 1985. The teacher chose a computer program each week which best fit the designated instructional objectives.

In designing and choosing the noncommercial software as well as choosing the commercial software, many factors were considered (see Appendix D). Much attention was given to how the textbook dealt with the various concepts covered. In creating the practice programs, the textbook was used as a guideline so as to be sure that the same variety of practice in the book would be offered through the computer practice. Establishing the variety of practice meant that if various aspects of the concept were stressed in the exercise problems in the book, a number of similar problems were included in the software.

Research Design

The design utilized in this study was the pretest-posttest control group design (see Figure 1). Two treatment groups were formed: Group A, CAI techniques, Group B, traditional classroom procedures. This design was chosen because it was considered essential to obtain a reliable measure of the effects of the treatment. And since five months had elapsed between pretest and posttest, possible interaction of testing and treatment was not considered to be a major threat to the external validity of the study. ✓

Instrument

The main instrument for this study was the Metropolitan Mathematics Instructional Test, Form J. This ✓

<u>Experimental Group</u>		<u>Pretest</u>	<u>Treatment</u>	<u>Posttest</u>
Computer Use n = 18	Intact Groups	MIMT: Form J*	Computer Usage with Regular Program	MIMT: Form J*
<u>Control Group</u>		<u>Pretest</u>	<u>Treatment</u>	<u>Posttest</u>
Noncomputer Use n = 36	Intact Groups	MIMT: FORM J*	Regular Instructional Program	MIMT: FORM J*

Figure 1. Experimental design.

*Metropolitan Instructional Mathematics Test.

test is a series of tests developed by systematic analysis of math textbooks, curriculum guides and lists of instructional objectives. While there were some differences in the mathematics materials analyzed, similarities were more frequent in occurrence. The Metropolitan Mathematics Instructional Test does cover most of the content for any particular mathematics program and provides the teacher with the basic information when planning an instructional program.

Validity of any achievement test is defined in terms of content validity. A test has content validity if the objectives and items adequately cover the curriculum. Since every school system's curriculum varies, it cannot be said that the Metropolitan Mathematics Instructional Test is always valid. Each school must judge the content validity of the instrument. To aid the school in this judgment, a Compendium of Instructional Objectives listing all objectives in the test is available. Also presented in the test manual is additional information describing the procedures used in developing the test content for the series. Reliability estimates using the Kuder-Richardson Formula 20 was .97.

Design and Statistical Analysis

The design used in this study was the pretest-posttest control group design. An Analysis of Covariance



(ANCOVA) was used to determine the degree of significance in gain scores from the pretesting to the posttesting. This was accomplished by comparing the F coefficients of the pretest scores and posttest scores with the values of the experimental and control groups to indicate significant difference at the .05 level of confidence. The ANCOVA was chosen because: there was a need to obtain information of the ability of each child at the beginning of the study; the subjects were not randomly assigned; and intact classes had been assigned as the treatment. The potential threat of pretest-posttest interaction was assumed to be minimized in this study since five months elapsed between testing. The hypothesis to be tested was:

There is no significant difference in the mean score, as measured by the Metropolitan Mathematics Instructional Test, between Chapter I students receiving traditional instruction (control group) and those receiving traditional instruction supplemented with computer assisted instruction (experimental group).

Collection of Data

The administration of the pretests was carried out in December 1984, and the posttest was administered in May 1985. There was a total of 67 students assigned to the

study—46 in the control group and 21 in the experimental group. At the end of the experiment there were complete sets of data available for 54 students (36 control and 18 experimental). The pretest and posttest were taken in four sessions to prevent fatigue of students. Each session averaged approximately one hour. Each group was given the test at the same time each session. The administrator gave the test as directed by the Metropolitan Mathematics Instructional Test manual.

CHAPTER IV

PRESENTATION AND INTERPRETATION OF RESULTS

Introduction

The investigation was designed and implemented to determine whether or not CAI would result in measurable gains in mathematic achievement of Chapter I secondary students at the .05 confidence level. For answering this experimental question the data were subjected to statistical treatment and were analyzed by the means of Analysis of Covariance. In confirmation for the requirement for Analysis of Covariance, a verification of a homogeneity of slope variation was calculated. The statistical findings of the treatment of data for the control and experimental groups are as follows: A summary of the F value for the mathematics control and experimental groups is presented in Table I. Table II contains adjusted posttest means of mathematics achievement scores while Table III contains means of mathematics achievement scores for control and experimental groups before adjustment for covariant. Table IV presents the attrition for the control and experimental groups.

TABLE I
SUMMARY OF F VALUE FOR CONTROL AND CRITERION VARIABLE*

Covariant	Criterion Variable	F Coefficient
Pretest	Posttest	.3689

F coefficient not significant at the .05 confidence level with 1,50 df.

*ANCOVA results for control and experimental groups of Chapter I students at Fulton High School, Knoxville City Schools, Tennessee, 1984-85.

TABLE II
POSTTEST MEANS OF MATHEMATICS ACHIEVEMENT SCORE
TABLE ADJUSTED FOR COVARIANT*

Group	Posttest Mean
C	122.586
E	126.828

*Results for control and experimental groups of Chapter I students at Fulton High School, Knoxville City Schools, Tennessee, 1984-85.

TABLE III

MEANS OF MATHEMATICS ACHIEVEMENT SCORE TABLE FOR CONTROL
AND EXPERIMENTAL GROUPS BEFORE ADJUSTMENT
FOR COVARIANT*

Group	Variable	N	Mean	SD
C	Pretest	36	123.694	20.71
C	Posttest	36	124.583	26.17
E	Pretest	18	117.167	16.59
E	Posttest	18	122.833	18.27

*Results for control and experimental groups of
Chapter I students at Fulton High School, Knoxville City
Schools, Tennessee, 1984-85.

TABLE IV

ATTRITION FOR THE CONTROL AND EXPERIMENTAL GROUPS*

	Control	Experimental
Pretest-N	45	21
Posttest-N	36	18
Attrition-%	20%	14%

*Results for control and experimental groups of
Chapter I students at Fulton High School, Knoxville City
Schools, Tennessee, 1984-85.

Presentation of Data

The Metropolitan Mathematics Instructional Test was administered as the pretest to both the CAI and non-CAI groups. Special treatment was administered to the CAI group during the 13-week period and both groups were post-tested using the same instrument used for the pretest. An Analysis of Covariance was used to compare the end achievement of both groups. Since the students were not randomly assigned and intact classes had been assigned as the treatment group, such a test was appropriate. The Analysis of Covariance uses as the basic observation the class means and treatment effects are tested against variation in these means. The covariant would be the pretest means (Stanley and Campbell, 1963).

The F coefficient on Table I was below the necessary value which would identify a statistically significant difference. Therefore based on these data, it was concluded that CAI in mathematics instruction did not result in significant gains in mathematics achievement of Chapter I students. Consequently, the proposed hypothesis was accepted:

There is no significant difference in the mean score as measured by the Metropolitan Mathematics Instructional Test, between Chapter I students receiving traditional

instruction (control group) and those receiving traditional instruction supplemented with CAI (experimental group).

A verification of homogeneity of slopes was calculated in confirmation of the requirement for Analysis of Covariance. The general linear model procedure in SAS was used (SAS Version 5 Ed., 1985). The interaction effect of pretest times group had an F value 0.03 which was not significant with a df (1,50). The F statistic 0.03 was not significant using an alpha level .1. Therefore it was concluded that the slopes were equal in the two groups, confirming homogeneity of slope.

The post score means of achievement scores presented in Table II (before the covariant) for both the experimental and control scores revealed an increase in scores. The increase for the control group was +.8889 and +5.669 for the experimental group. Even though the increase is substantial it is not significant due to the high pretest scores of the control group.

By referring to Table III it can be noted that the pretest means of both groups are not equivalent when the special treatment (covariant) was administered. Looking at the posttest means in Table II which have been adjusted, the control mean has been lowered to 122.586 and the experimental mean has been raised to 126.828. This adjustment takes into account the initial difference of the control and experimental group pretest scores.

At Fulton High School there were 66 students originally assigned to both the experimental and control groups. All these students completed the pretest. An analysis of the attrition indicates an attrition loss of nine students in the control group (20%) and a loss of three students in the experimental group (40%). This was attributed to lack of willingness to continue with the experiment and family relocations during the experiment between the times of pretest and posttest.

CHAPTER V

SUMMARY, FINDINGS, DISCUSSION, AND RECOMMENDATIONS

Since the incorporation of microcomputers as an instructional aid in mathematics, much time, effort, and money have been employed to create computer programs to help students memorize simple skills, learn concepts, and integrate these skills and concepts into today's society. Even with all this effort, CAI is not being used as effectively as possible simply because educators are uncertain about how to utilize it more efficiently in the curriculum. This confusion could possibly be due to the fact that validating CAI studies were always performed in controlled laboratory situations (not classrooms) while students participated at a computer mainframe terminal and responded to information or questions presented to them by the system. All of this was overseen by professionals in the CAI field and not classroom teachers.

Summary

The major purpose of this study was to determine the effectiveness of computer assisted instruction in the classroom. Math achievement scores of Chapter I students receiving only traditional instruction were compared to

achievement scores of Chapter I students using computer assisted instruction. Chapter I students from grades 9, 10, 11, and 12 at Fulton High School, Knoxville, Tennessee, were chosen. Form J of the Metropolitan Instructional Mathematics Test was administered to establish the initial level of students' mathematical achievement. Thirty-six students were in the control group and 18 students were in the experimental group. The 18 students in the experimental group utilized computers in math instruction and the 36 students in the control group did not. To control for variation, each group was taught by the same teacher, used the same textbooks, curriculum guide and materials. Both groups were tested after a 13-week program by the Metropolitan Instructional Mathematics Test, Form J. The scores of both the computer assisted instruction group and the control group were compared by using an Analysis of Covariance. The results of this analysis indicated that computer assisted instruction did not result in significant gains in mathematics achievement of Chapter I students.

Findings

The F score obtained for mathematics achievement was .3689 which was not significant at the .05 confidence level with (1,50) df. The null hypothesis proposed in the study was accepted:

There is no significant difference in the mean score, as measured by the Metropolitan Mathematics Instructional Test, between Chapter I students receiving traditional instruction (control group) and those receiving traditional instruction supplemented with computer assisted instruction (experimental group).

Discussion

The premise of this study was to assess the effectiveness of CAI implemented under as normal classroom conditions as possible, deemphasizing the controlled laboratory situations in which most CAI is carried out and to perform integration of CAI into the traditional classroom. There was a review of literature relating to various aspects of this integration. First, the basic characteristics of CAI were reviewed. These characteristics included the advantages of CAI, the uses of CAI and its various modes. Secondly, research was reviewed into the process to be followed in order to evaluate software effectively and efficiently. Further research was reviewed into the educational learning strategies and theories associated with using CAI. Each of these aspects were taken into consideration when planning the implementation of CAI into these Chapter I math classes.

In examining the results of this study, many factors should be kept in mind which could have had an effect on the conclusion.

To facilitate normal day-to-day educational practices many compromises were made in the experimental design which may explain the results. Intact classes were used instead of randomizing the students. In the real world of educational practice, the scheduling of students is determined by their curricular needs, not experimental design. Also, individual CAI computer time was influenced by school activities, school holidays, and student absenteeism.

The instrument chosen to measure significant gains may have been inappropriate for the variable being used, and the history of the population chosen may also have had an effect on the study. (The two groups that were randomly assigned as the experimental group had the lowest pretest means. This factor should be taken into consideration also.) The effects may have been different if the population had been a more diverse group combining students from low, middle, and high economic backgrounds as well as combining students with low, middle, and high scholastic achievement.

Another factor that could have influenced the results of this study was the lack of a variety of teachers

to implement the experimental teaching method. With a lack of teacher variety, instructional efforts could be easily manipulated (i.e., if a teacher is aware of research design he/she could easily increase efforts on controlled or experimental instruction). The results could have been different if more than one teacher had conducted the experimental treatment throughout the day.

Also, the overall effectiveness of the Chapter I program at Fulton High School could have had an effect on the subjects. The results could have been different if another Chapter I class in another school had been used.

Even though the pretest scores of both the experimental and control groups were not at the same initial level of skill and results of analysis indicated that CAI did not result in any significant gains in mathematics achievement, the trend seems to be that the experimental group improved the most. An overview of the data shows the gain score posttest means of the experimental group was higher than the control group before and after the means were adjusted. CAI is not the panacea for all problems in mathematics achievement but the results from this investigation show CAI is a positive educational approach that would benefit students and can be used to enhance learning.

Recommendations

Only a small population segment was used with this study, therefore the present investigator offers the general recommendation that more studies should be taken over a longer duration of time with a larger diverse population of intact groups despite the nonsignificance of the findings.

The following research questions have been raised:

1. What effect did the overall effectiveness of the Chapter I program at Fulton High School have on the subjects? Would the results have been the same if another Chapter I class in another school had been used?
2. What effect did the limited "ends" have on the results of the study?
3. Would the experimental treatment have a greater impact on the subjects if the investigation was conducted over a 1- or 2-year period? It is possible that the 13-week treatment did not result in a realistic representation of the effects.
4. What effects would the treatment have had on a different population, such as a more diverse group of low, middle, and high economic traits, or low, middle and high achievement traits?

5. Did the personality and teaching techniques of the instructor effect the results of the study? Would the results have been different if another or more than one teacher had conducted the experimental treatment throughout the day?

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APPENDICES

APPENDIX A

CONSENT LETTERS



KNOXVILLE BOARD OF EDUCATION

101 East Fifth Avenue, Knoxville, Tennessee 37917
Telephone (615) 544-3600

Dr. Fred Bedelle, Jr., Superintendent

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Roy W. Wallace

October 29, 1984

Dear Parent(s) and Student(s):

I am conducting a study to determine if computer-assisted instruction will improve math skill performance of Chapter 1 students. Chapter 1 math classes will be randomly divided into two groups. The two groups will be tested at the beginning of the study and at the end of the study with a standardized test which measures mathematical skills. The two test scores will then be compared to determine the effectiveness of Computer-Assisted Instruction in Chapter 1 mathematic classes.

Each group will be taught by the same teacher and will use the same textbooks, curriculum guide and materials. The only difference between the groups will be the use of the computer in the classroom. Any information obtained from the students and students' achievement tests will be confidential. Nowhere in the study will the names of the individuals be used.

Please complete the bottom portion of this letter if your child has permission to participate in the study. Have your child return this permission slip to his/her math teacher as quickly as possible. Your child may withdraw from this study at any time without penalty of any nature. This study is voluntary.

Please do not hesitate to call or write me if there are any questions:

Robert L. Davidson
The University of Tennessee
10 Claxton Education Building
Knoxville, TN 37996-3400
Phone work - 974-5037; home - 588-1073

Sincerely,

Robert L. Davidson

RLD:cv

I have read the explanation concerning the study of computer-assisted instruction in Chapter 1 classes.

I give my consent for my child to participate in the study.

Name of Child _____

Parent's Signature _____

Student's Signature _____

Date _____

October 31, 1984

Robert L. Davidson
10 Claxton Ed. Bldg.
CAMPUS

Dear Mr. Davidson:

The project which you submitted entitled, "The Effectiveness of CAI in Chapter I Math Classes at the Secondary Level," CRP #A-274, has been reviewed.

This project comes within the guidelines which permit me to certify that the project is exempt from review by the Committee on Research Participation.

The responsibility of the project director includes the following:

1. Prior approval from the Dean for Research must be obtained before any changes in the project are instituted.
2. A statement must be submitted (Form D) at 12-month intervals attesting to the current status of the project (protocol is still in effect, project is terminated, etc.).

The Committee wishes you success in your research endeavors.

Sincerely,

Marla Peterson
Dean for Research

SCW

cc: Dr. C. W. Minkel, Acting Vice Provost for Research
Dr. Arnold R. Davis
Dr. D. J. Dessart

FORM A

THE UNIVERSITY OF TENNESSEE, KNOXVILLE

Certification of Exemption from Review
for Research Involving Human Subjects

Project Director and Co-Director:

Address and Phone Number of Project Director and Co-Director:
(For student projects, list both student and advisor.)

Robert L. Davidson 3700 Sutherland Ave.
Knoxville, TN 37919 974-5037

Title of Project:

The Effectiveness of CAI in Chapter I Math Classes on the
Secondary Level

Department: Education Curriculum and Instruction

Supporting Agency and Identification Number (if known):

Estimated starting date and completion date: 12/1/84 - 5/1/85

Grand submission deadline:

- I. Objective(s) of Project: The purpose of this study is to compare math achievement scores of Chapter I students receiving both computer assisted instruction (CAI) and traditional instruction versus groups receiving only traditional instruction.
- II. Subjects (selection method, population, description): The samples for this study will be 9th, 10th, 11th, and 12th grade Chapter I students at Fulton High School (Knox City Schools, Tennessee). Each Chapter I class contains from 9 to 12 students. The students who are involved in the Chapter I program have failed to achieve 80% of grade level objectives on the Knoxville Basic Skills Test (grades 1-9), or failed to demonstrate proficiency on the State Proficiency Test (grades 10-12). (Chapter I Handbook, 1984-85). The classes will be randomly assigned to one or two groups.
- III. Methods or Procedures: The design to be used in this study will be a pretest-posttest control group design. The Metropolitan Instructional Math Test, Forms J and K will be administered as the pretest and posttest to both the experimental and control group.

A pretest will be given to establish the initial level of their mathematical achievement. During twelve weeks' treatment, one group will utilize CAI in math instruction and the other group will not. Each group will be taught by the same teacher and will use the same textbooks, curriculum guide and materials.

At the end of the twelve-week period both groups will be post-tested to determine the ending level of their achievement. The scores of the CAI group and the non-CAI group will be compared using a T test.

IV. Category of Exempt Research per 45 CFR 46: _____
(See reverse side of form for Exempt Categories)

Certification: The research described herein is in compliance with 45 CFR 46 101(b) and presents subjects with no more than minimal risk as defined by applicable regulations.

Signatures:

Investigator _____ Date _____

Advisor _____ Date _____

Department Head or Chair _____
of Departmental Review Committee Date _____

Dean for Research

APPENDIX B

INSTRUCTIONAL FORMAT

INSTRUCTIONAL FORMAT

Subject: _____

Name: _____

Grade: _____

Lesson Plan Title: _____

Date: _____ Time: _____

I. Long Range Objective(s)/Unit Goal:

II. Instructional Objectives:

III. Set:

IV. Instruction:

V. Closure:

VI. Options:

VII. Reminders:

VIII. Self-Evaluation:

INSTRUCTIONAL FORMAT

Long Range Objective(s)/Unit Goal

- A statement of intent, direction, or purpose
- Long term
- Broad
- Timeless
- Nonspecific

Instructional Objectives

- A statement of anticipated learner outcome that is short-term, specific, and measurable.
 - "As a result of this lesson, the learner will be able to . . ."
 - Could include particular conditions
 - Could state level of performance

Set

- Introductory statements which would prepare the students for the lesson
- Should include motivational aspect
 - Should involve the students actively (warm up activities)
 - Build on previous learning
 - Relate to student's life or real life experiences
- Label the learning (state learner objectives)

Instruction

Including, but not restricted to:

- Content--input
- Materials--resources--equipment
- Teacher strategies--procedures--alternatives
 - Advance organizers
 - Monitor (check for understanding) and Adjust (alternatives for reteaching)
 - Modeling (methods the teacher uses to demonstrate the desired behavior/skill)
 - Provide examples
 - Supervised practice
 - Transitions
 - Assignment

Motivation

Retention

Reinforcement

Active Participation

Principles of Learning

Closure

- Ties together the lesson
 - Summarize
 - Restate/verbalize
 - Review
 - Do one more time
 - Wrap it up
 - Prepare for what is to come
- Involve students actively

Options (for follow up)

- Independent practice and enrichment or supplementary activities to extend the learning
- Reteach (using alternative approaches) and independent practice

APPENDIX C

WEEKLY LOG REPORT

WEEKLY LOG REPORT

Name _____

Date _____

Class Period and Time _____

Instructional Objective:

Time on Computer (If Applicable)

Software Used (If Applicable)

Independent Practice _____

APPENDIX D

COMMERCIAL SOFTWARE USED

COMMERCIAL SOFTWARE USED

A. Name of Program: Basic Math Competency Skill Building:
Fractions

Author: Michael P. Conlon

Publisher: Educational Activities, Inc.

Description of Program:

Basic Math Competency Skill Building: Fractions consists of eight lessons which are sequential in teaching objectives and build upon the previous program for each of the four major mathematical operations, and each of these is broken down into three levels of difficulty. This program is a combination of drill and practice and tutorial.

B. Name of Program: Percentages

Author: Philip E. Hessemer

Publisher: Educational Activities, Inc.

Description of Program:

Percentages consist of three levels which are sequential in teaching objectives and building upon each level. The levels in sequential order are:

- a. Introduction to percents (rewriting a decimal as a percent).
- b. Rewriting a fraction as a percent.
- c. Finding a percent of a number.

These percentage levels are designed to provide the student with an explanation of a specific phase of "percent problems," as well as unlimited sets of examples. This program is a combination of drill and practice and tutorial.

APPENDIX E

OUTLINE OF THE ADVANCED 1 MATHEMATICS
INSTRUCTIONAL TEST, FORM J

Outline of the Advanced 1 Mathematics
Instructional Test, Form J

<u>Test</u>	<u>Objective</u>	<u>Number of Items</u>
Numeration (36 items)	30 Completes simple number sequence from a pattern	3
	31 Rounds numbers to nearest 10, 100, and 1000	3
	32 Converts fraction to an equivalent fraction	3
	33 Identifies position of rational numbers on number line	3
	34 Converts between standard and exponential notation	3
	35 Follows directions in a simple flow chart	3
	36 Identifies prime and composite numbers and prime factors	3
	37 Recognizes when fractions = decimals (tenths, hund., thous.)	3
	38 Can determine greatest common factor	3
	39 Can determine least common multiple	3
	40 Determines solution sets for simple inequalities	3
	41 Translates fractional numerals to equivalent decimal numerals	3
Geometry & Measurement (45 items)	25 Selects English units for expressing measurements	3
	26 Selects metric units for expressing measurements	3
	27 Knows metric prefixes and relationships among them	3
	30 Can estimate measurements-English units	3
	31 Can estimate measurements-metric units	3
	32 Knows relationships among English and metric units	3
	33 Can identify points, lines, and line segments	3
	34 Identifies and knows properties of parallel, intersecting, and perpendicular lines	3
	35 Performs +, -, or x (English units), with changes in units	3
	36 Estimates degrees of angles and reads protractor	3

<u>Test</u>	<u>Objective</u>	<u>Number of Items</u>
	37 Identifies simple geometric constructions	3
	38 Knows relationships among lines (segments, rays) and points	3
	39 Knows relationships between ordered pairs of numbers and points on graph	3
	40 Knows relationships among angles formed by intersecting and parallel lines	3
	41 Determines area of squares, rectangles, and right triangles	3
Problem Solving (24 items)	9ND No limit; number sentence; dictated	3
	9NR No limit; number sentence; read	3
	9NX No limit; extraneous information; number sentence; read	3
	9SD No limit; solve; dictated	3
	9SR No limit; solve; read	3
	9SM No limit; multi-step; solve; read	3
	9SX No limit; extraneous information; solve; read	3
	9SZ No limit; multi-step; extraneous information; solve; read	3
Operations: Whole Numbers (24 items)	<u>Multiplication</u>	
	M3 Basic facts 1-9; missing factor	3
	M5 2d and 1d; regrouping required	3
	<u>Division</u>	
	D3 Basic facts 1-9; missing dividend or divisor	3
	D5 2d and 1d; with remainder	3
	<u>All operations, unlimited</u>	
	A7 Add; unlimited	3
	S8 Subtract; unlimited	3
	M7 Multiply; unlimited	3
	D7 Divide; unlimited	3
Operations: Laws & Properties (24 items)	12 Knows associative property of add. and mult. and can use them	3
	13 Recognizes multiplication and division as inverses	3
	14 Knows and uses rules for order of operations	3
	15 Knows meaning of Closure Property and can use it	3

<u>Test</u>	<u>Objective</u>	<u>Number of Items</u>
	16 Can multiply and divide numbers with exponents	3
	17 Can add and subtract denominate numbers	3
	18 Can multiply and divide denominate numbers	3
	19 Can use Distributive Property of Mult. and Division over Add. and Subt.	3
Operations: Fractions & Decimans (45 items)	02 Can add fractions, like denominators, with reducing	3
	03 Subtracts fractions, like denominators, no reducing	3
	04 Subtracts fractions, like denominators, with reducing	3
	05 Multiplies 2 fractions, no reducing	3
	06 Multiplies 2 fractions, with reducing	3
	07 Can add decimals	3
	08 Can subtract decimals	3
	09 Can add fractions and unlike denominators	3
	10 Can subtract fractions with unlike denominators	3
	11 Can multiply fractions and whole numbers	3
	12 Can divide 2 fractions	3
	13 Can divide fractions and whole numbers	3
	14 Can multiply decimals	3
	15 Can divide decimals	3
	16 Can compute with percents	3
Graphs & Statistics (24 items)	02 Can read bar and picture graphs (literal)	3
	03 Can draw inferences from bar and picture graphs	3
	04 Can determine probability of an independent event	3
	05 Can read data from a table (literal)	3
	06 Can draw inferences from tabled data	3
	07 Can determine average (mean) of data from a table	3
	08 Can interpret a frequency distribution	3
	09 Determine combined probabilities and probability of event not occurring	3

VITA

Robert Lloyd Davidson was born in Macon, Georgia, on October 31, 1948. He moved to Unadilla, Georgia, attending and graduating from Unadilla Elementary and High School. In 1966 he entered Middle Georgia College, Cochran, Georgia, and graduated with an Associate degree. In 1968 he entered Valdosta State College, Valdosta, Georgia, and received a Bachelor of Science degree in Elementary Education.

From 1970 to 1971 he taught fourth and fifth grade mathematics at Unadilla Elementary School. From 1971 to 1973 he was in the United States Army. From 1973 to 1980 he taught school in Fayetteville, North Carolina. His teaching experiences while there included fourth, fifth, sixth, and seventh grade mathematics and science. He was also the junior varsity basketball, track and field, and cross country coach. During this time he also received his Master of Arts degree in Education from the University of North Carolina, Charlotte.

From 1980 to 1982 he taught eighth grade mathematics at Easley Junior High School in Easley, South Carolina. In the fall of 1982 he entered the doctoral program at The University of Tennessee, Knoxville, with a major emphasis in Mathematics Education, with collateral areas of emphasis

in Science Education and Educational Leadership. In the fall of 1985 he became an Assistant Professor at East Tennessee State University, Johnson City, Tennessee, in the Department of Developmental Studies.