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ABSTRACT

This document reports the results of a 4-month experimental study designed to determine the effectiveness of using computers with interactive software programs to teach higher-order thinking skills. The effects of CAI (computer-assisted instruction) on affective domains were assessed, as well as the effectiveness of CAI with interactive software programs in the areas of making inferences, making generalizations, and math problem solving. Sixty-one first graders and 70 second graders participated in the study, with an experimental group receiving CAI 30 minutes a week for four months. Afterward, all of the subjects' 1992 scores on inferences, generalizations, and math problem solving subtests of ITBS, including scores on four affective domains, were analyzed. A statistically significant difference was found between CAI and non-CAI groups in generalizations and math problem solving, and in affective domains such as attitude toward school, attitude toward computers, and skills students could do with computers. The impact of CAI on students' overall academic achievement and self-concept was not statistically significant; however, the effect size was greater at the first-grade level than at second-grade level. The same held true with grade level equivalent in reading and math. The statistical findings of this study suggest that: (1) CAI with varieties of interactive software is an effective tool to teach higher-order thinking skills; (2) it is developmentally appropriate to expose first-graders to a computerized environment; and (3) CAI is more effective in enhancing affective domains than cognitive domains. Appendices include copies of letters of approval, details concerning the software used in the study, and questionnaires and worksheets used in the student attitude measure. (Contains 16 tables and 94 references.) (BEW)

EFFECTS OF USING INTERACTIVE CAI ON PRIMARY GRADE STUDENTS' HIGHER-ORDER THINKING SKILLS: INFERENCES, GENERALIZATIONS, AND MATH PROBLEM SOLVING

A DISSERTATION

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

IN THE GRADUATE SCHOOL OF THE

TEXAS WOMAN'S UNIVERSITY

COLLEGE OF EDUCATION AND HUMAN ECOLOGY

BY

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DENTON, TEXAS

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DENTON, TEXAS

JUNE 30, 1992
Date

To the Dean for Graduate Studies and Research:

I am submitting herewith a dissertation written by Iheanacho I. Orabuchi, Sr. entitled "Effects of Using Interactive CAI on Primary Grade Students' Higher-Order Thinking Skills: Inferences, Generalizations, and Math Problem Solving." 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 Ph.D. with a major in Early Childhood Education.

Sam Ed Brown

Dr. Sam Ed Brown, Major Professor

We have read this dissertation and recommend its acceptance:

Department Chairperson

Dean of College

Accepted
Leslie M Thompson

Dean for Graduate Studies and Research

DEDICATION

To my parents, Michael and Lucy Orabuchi, who never dillydallied in inspiring me.

To my wife and kids, Ngozi, Nkechi, Iheanacho, Jr., Chinedu, Chinwe, and Chukwumeziri, whose support, encouragement, and love never oscillated throughout this endeavor.

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appreciate the understanding and patience of my children who have waited so long for me to have time to play.

ABSTRACT

EFFECTS OF USING INTERACTIVE CAI ON PRIMARY GRADE STUDENTS' HIGHER-ORDER THINKING SKILLS: INFERENCES, GENERALIZATIONS, AND MATH PROBLEM SOLVING

Iheanacho Ikedinobi Orabuchi

August 1992

This was a 4-month experimental study designed to determine the effectiveness of using computers with interactive software programs to teach higher-order thinking skills. Also, the effects of CAI on affective domains were examined. The effectiveness of CAI with interactive software programs were assessed in the areas of inferences, generalizations, and math problem solving with 61 first-grade and 70 second-grade children participating in the study. The subjects were divided into two groups: control group and experimental group, which received CAI with interactive software programs designed to teach higher-order thinking skills for a period of 4 months. The subjects; 1992 scores on inferences, generalizations, and math problem solving subtests of ITBS, including scores on four affective domains, were analyzed by a series of analysis of variance

(ANOVA). It was found that there was a statistically significant difference between CAI and Non-CAI groups in generalizations, math problem solving, and in affective domains such as attitude toward school, attitude toward computers, and skills students could do with computers. The impact of CAI on students' overall academic achievement and self-concept was not statistically significant. However, the effect size was more at the first grade level than at second grade level. The same was true with grade level equivalent in reading and math. The statistical findings for this study led to these conclusions: (a) CAI with varieties of interactive software programs is an effective tool to teach higher-order thinking skills, (b) it is developmentally appropriate to expose first-grade students to computer environment, and (c) CAI is more effective in enhancing affective domains than cognitive domains.

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CHAPTER I

INTRODUCTION

Background

Educators are constantly under immense pressure from the public to find a way to help students achieve academically. It is the opinion of the public that our students are not learning as well or as much as they should. This notion is evidenced when some educators are calling for more accountability at the elementary level (Bennett, 1986; Bloom, 1986; Price, 1989). As a result of the public notion of the state of students' academic performance, teachers are willing to try almost any tool or method in their respective classrooms that will enhance the academic learning of their students.

The call for "back to basics," (Bitter, 1987) might undoubtedly be a necessary one; however, it is in no way a sufficient condition that will revolutionalize the test-driven curriculum inherent in our public schools. The students' ability to think has not been adequately encouraged in our public schools. Willis, Hovey, and Hovey (1987) argue that the curriculum of many schools does not pay attention to higher-order thinking skills. It has been reported that recently Americans have come to realize that our elementary and secondary school students are not thinking as critically and skillfully as we may want them to (Marzano, Brandt, Hughes, Jones, Presseisen, Rankin, & Suhor, 1988). They believe that critical thinking is the foundation of learning and that higher-order thinking skills are inseparably linked to the success in the content-area knowledge acquisition.

Price (1989) reports that our students compare unfavorably with students from other industrialized nations in math and science. Since higher-order thinking skills are foundations of math and science, this may be one reason why our students are lagging behind in those areas. Marzano et al. pointed out that a major problem in American education lies in the fact that our students are deficient in higher-order thinking skills. As a result of this, some educators and businesses have joined in stressing that the goal of education should be to produce students who are adequately trained to think well and solve problems (Pfeiffer, Feinberg, & Grelber, 1987). They also believe that if we expect our children to be both productive thinkers and problem solvers we should teach them how to do so. It has been suggested by research that problem solving skills have not been effectively taught in our schools (Pfeiffer et al., 1987).

Rationale

Educators have been led to believe that whenever the issues of student's low academic performance are raised, in this case deficiency in higher-order thinking skills (generalizations, inferences, and math problem solving), they have to first examine their instructional methods in the process of dealing with the issue. They do, in fact, have several instructional techniques or approaches at their disposal. However, choosing the appropriate one or the "right mix" for students has proved to be difficult because of individual differences inherent in the student population in the classroom.

We are now witnessing advanced technologies gradually, but surely, creeping into our classrooms. In most cases they are being used for drill and practice purposes. What effect will they have on students' academic performance in general and higher-order thinking skills in particular?

Statement of the Problem

Deficiency in higher-order thinking skills among our students is a serious problem. These skills include inferences, generalizations, and math problem solving. Another problem is the lack of an effective method of teaching these skills. There is public pressure to produce students who can think well and solve problems. This pressure results from the manifestation of the deficiency in higher-order thinking skills among our secondary school students. It is believed that this deficiency is deep-rooted. That is, the deficiency in higher-order thinking skills starts appearing in the primary grades and progressively becomes greater thereafter.

Granted that higher-order thinking skills are the foundation for learning, their deficiency starts appearing in the primary grades, and we lack an effective approach for teaching these skills. A possible approach to solving the deficiency problem is that we assess the effects of teaching primary grade students higher-order thinking skills with computer-assisted instruction (CAI). According to Bloom (1986) the key to academic success in middle and secondary schools is undoubtedly the quality of instruction and learning in the elementary school.

Several studies in computer-assisted instruction (CAI) in a variety of educational settings have claimed its effectiveness in teaching basic concepts in reading and math. However, no study has focused on the effectiveness of CAI with varieties of interactive computer software in teaching higher-order thinking skills like inferences, generalizations, and math problem solving in the primary grades--pre-kindergarten to third grade. Few studies have focused on the impact of Logo and programming related computer software on the cognitive development of children.

Purpose

The primary purpose of this study was to investigate and assess the effectiveness of computer-assisted instruction (CAI) on primary grade students' higher-order thinking skills. This was done by differentiating groups of students by grade level and reception or failure to receive CAI. A variety of interactive computer software in teaching higher-order thinking skills in first and second grades was used. Again these skills include inferences, generalizations, and math problem solving.

Secondly, this study examined the impact of CAI with varieties of interactive computer software on overall academic achievement. In addition, this study assessed the impact of CAI on students' self-concept, attitude toward school, attitude toward computers, and the skills they could learn or do with computers.

Significance of the Study

This study attempted to provide some insights on the effectiveness of using computers to teach the much needed higher-level thinking skills in the primary schools. It also provoked need for further studies on finding effective ways to teach inferences, generalizations, and math problem solving in the primary grades considering their respective levels of cognitive development.

Research Questions

This study focused on the effectiveness of using computer-assisted instruction with varieties of interactive computer software programs to teach inferences, generalizations, and math problem solving in grades one and two. As a result, the following research questions were addressed.

1. Will students who received CAI with varieties of interactive computer software in inferences, generalizations, and math problem solving score higher in those skills than do those students who did not receive CAI?

2. Will higher-order thinking skills--the ability to infer, generalize, and do math problem solving--have a significant relationship with students' overall academic achievement?

3. Will the use of CAI with varieties of interactive computer software affect students' attitude toward school, attitude toward computers, their positive self-concept, and the skills they could learn with computers?

Assumptions

The following assumptions were made by this study:

1. Higher-order thinking skills can be taught.

2. CAI or computers are appropriate media or tools for teaching.

3. Primary grade students are capable of learning higher-order thinking skills.

Hypotheses

Ho 1: There will be no statistically significant difference in inferences, generalizations, and math problem solving subtest scores of ITBS, including grade equivalent scores in reading and math between students who received CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months and those students who did not receive CAI.

Ho 2: There will be no statistically significant difference in overall academic achievement measured by the ITBS composite scores between experimental and control groups or grades one and two.

Ho 3: There will be no statistically significant difference between the experimental and control groups or grades one and two in their self-concept, attitude toward school, attitude toward computers, and the things or skills they could learn to do with computers.

Ho 4: There will be no statistically significant difference in inferences subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.

Ho 5: There will be no statistically significant difference in generalizations subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.

Ho 6: There will be no statistically significant difference in math problem solving subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.

Definition of Terms

Higher-Order Thinking Skill--this is synonymous with higher-level cognitive skill or higher-level thinking skill. It is "the ability to take information, organize it into meaningful units, extract the essence or principles of truth contained in the information, and then put it to work solving other problems. These are all characteristics of good thinking style. Whether we call it process thinking, reasoning, or problem solving, the process is a mental one, and it calls for individuals to use all their intellectual faculties to the fullest" (Willis et al., 1987, p. 114).

Higher-level cognitive skill involves analysis--ability to break information down into components so that their relationships will be understood; synthesis --the ability to create a new whole by putting components or parts, or elements together; and evaluation--the ability to make judgments regarding the value of ideas contained in an information or situation (Willis et al., 1987). According to Willis et al. (1987) "the skill of evaluation requires the learner to appraise, summarize, contrast, compare, conclude, argue, consider, and both understand and use external standards" (p. 122).

<u>Inferences</u>--inferences are cognitive processes involved in making interpretative meanings. According to ITBS objectives, inferences involve the following:

- the cognitive ability to understand cause and effect, concomitance, and interaction.
- the cognitive ability to infer feelings, emotions, traits, reasons, and motives of characters in a selection or situation.
- the cognitive ability to draw conclusions from information and relationships.

Generalizations--generalizations are cognitive processes involved in making evaluative meanings. According to ITBS objectives, generalizations involved the following:

- the cognitive ability to recognize the topic or main idea of a selection or paragraph.
- the cognitive ability to comprehend or understand the organization of a selection or a paragraph.
- the cognitive ability to apply information through prediction or generalization.
- the cognitive ability to recognize authors' viewpoint, attitude, and motive.
- the cognitive ability to recognize mood of a selection and qualities of style or structure.
- the cognitive ability to interpret figurative language.

Math Problem Solving--math problem solving is a cognitive ability to analyze and resolve perplexing math problems stated in words. It is comprised of single and multiple steps involving addition, subtraction, multiplication, and division. According to Tennyson and Rasch (1988), problem solving processes require "an active cognitive awareness (i.e., metacognition) of both differentiation and integration" (p. 373).

CAI--according to Computer Dictionary for Everyone, computer-assisted instruction (CAI) is defined as "the use of the computer to augment the individual instruction process by providing the students with programmed sequences of instruction under computer control. The manner of sequencing and progressing through the materials permits students to progress at their own rate" (Spencer, 1979, p. 50). Dictionary of Information Technology defines CAI as "the use of a computer to provide information to a student, pose questions and react to the student's response, e.g. by providing remedial information in a case of incorrect response. The system may provide sophisticated graphic displays or simulations of complex systems. Speech recognizers, speech synthesizers, touchscreen inputs, etc. provide opportunities for very sophisticated student machine interaction" (Longley & Shain, 1986, p. 65).

CAI is instruction and learning that occurs during interaction between the software program and the students using the computer (Viteli, 1989). Software is a set of computer programs, procedures, and related materials designed to solve specific applications (Viteli, 1989).

Self-Concept--self-concept is the total knowledge of self. It is a perception of self that includes feelings, attitudes, and total knowledge of one's abilities, skills, appearance, and social cognition and social acceptability.

Attitude--according to Mager (1968) "attitude is a word used to refer to a general tendency of an individual to act in a certain way under a certain condition" (p. 14). Generally, attitudinal tendency is based on visible behavior.

Delimitations

This study was conducted and the results were analyzed within the following confines or limitations:

1. Only one elementary school in a large urban public school system in the Southwest participated.

2. Only subjects in the primary grades--grades one and two were involved.

3. Inferences, generalizations, and math problem solving subtests of ITBS may not be the most effective measures to evaluate or assess higher-order thinking skills. The ITBS subtest scores were utilized in this study because of time and cost.

4. There was an instructional time lapse of about 5 months between the time the pretest (ITBS, 1991) was administered and the inception of the treatment.

However, whatever the impact of the lapsed time, it was assumed to be similar for both the experimental and control groups.

CHAPTER II

REVIEW OF RELATED LITERATURE

Theoretical Framework for CAI

Many CAI programs are based on behaviorist theories. The classical conditioning theory under Watson and Pavlov believes that learning occurs as a result of the association between a stimulus and the response, and after a reasonable practice, an unconditioned stimulus will start to elicit a conditioned response that was initially elicited with conditioned stimulus (Kaiser, 1985). This theory is the foundation of CAI programs designed for drill and practice. The drill strategy assumes that giver a reasonable amount of practice, a skill or concept can be learned (Kaiser, 1985). Though drill appears to be a good instructional strategy to teach simple facts, it is very deficient in teaching complex skills.

Operant conditioning theory under Skinner and Thorndike believes and emphasizes that the organism has to be rewarded in order to reinforce the elicited response and to enhance the chances of similar behavior occurring in the future (Kaiser, 1985). In this theory rewards already given as reinforcements may be withdrawn to extinct unwanted responses (Kaiser, 1985). Most of the CAI programs are based on this theory. While the response in the operant conditioning mode is voluntary, it is not voluntary in classical conditioning.

Golub (1984) notes that behaviorist theories are the major theoretical base in the development of CAI programs. These theories stressed the following procedures: learn small skills one-at-a-time, reward the learner for success, and order skills in a hierarchy of abstraction.

Erickson's psychosocial development theory's place in CAI is in its application. This theory embodies developmental stages, each comprised of tasks or crises that have to be resolved in order for a superior development to take place (Shade, 1985). These stages --autonomy, initiative, and industry--can be applied to CAI in the primary grades. Autonomy is a growing sense of power resulting from the feeling of being in control (Shade, 1985). Shade and Watson (1990) and Shade (1985) note that through the interaction with computers children master this complex technology and CAI interactions lead to an increased sense of power and autonomy. Apparently from the increased sense of autonomy emerges strings of initiative (Shade, 1985; Shade & Watson, 1990). It is believed that as mastery of CAI or computers through discovery-based programs continues, initiative behavior continues to increase (Shade, 1985). Shade (1985) defines initiative as the logical desire a child has to discover all he can control. From a successful initiative stage a child will delve into industry. Shade (1985) defines industry as the "ability to master the social skills necessary to complete and function successfully in the society in which the child lives" (p. 12). Mastery, being a successful achievement of industry, relies heavily on the surrounding social conditions, especially on the physical conditions--in this case computer technology.

This process of resolving one crisis after another through the mastery of computer usage will not only help a child develop adequately in each stage, but will go a long way to enhancing the child's self-esteem and self-concept. This suggests that providing primary grade students with the opportunity to interact with computers is a viable thing to do.

Cognitive and Information Processing Theories

CAI behaviorist based programs are not appropriate for higher-order thinking skills. "In place of the mechanistic, computational, behavioristic approach so widespread in the transmission of knowledge, computers can enable children to be active in the construction of knowledge" (O'Brien, 1987, p. 34). As a result, any study designed to assist in developing higher-order thinking skills will be ingrained in a large measure in a cognitive and information processing theory.

It is apparent that several classes of cognitive consequences emanate from the utilization of CAI. Two of these classes are subject matter knowledge acquisition and acquisition of higher-order thinking skills (Mandinach, Linn, & Fisher, 1983). These higher-order thinking skills include inferences, generalizations, and math problem solving. Tennyson (1989)) states that higher cognitive skills involve cognitive processes directly associated with the utilization of knowledge in solving problems. These processes, according to Tennyson (1989), are instrumental in helping individuals to restructure their existing knowledge by analyzing unexpected situations, conceptualizing the situation, defining the problem the situation brings, and coming up with a possible solution.

Cognitive theory holds that learning results from the cognitive processes that occur inside the organism as the organism interacts with the environment (Kaiser, 1985). What is learning? According to Argyris (1982), learning is "a process in which people discover a problem, invent a solution to the problem, produce the solution, and evaluate the outcome, leading to the discovery of new problems" (p. 38). This suggests that finding a solution to a problem creates further learning opportunities. Learning is an active construction of knowledge. Piaget (1970) and Papert (1980) believed that learning occurs as children construct their own knowledge. Shade (1985) and DeCorte (1990) hold that a child is an active participant in constructing and acquiring knowledge. Out of four themes that are central to learning--structure, readiness, intuition, and desire to learn--application of intuition is immensely important in the acquisition of higher-order thinking skills (Bruner, 1977). Intuition, according to Bruner (1977), is "the intellectual technique of arriving at plausible but tentative formulations without going through analytic steps by which such formulations would be found to be valid or invalid conclusions. Intuitive thinking, the training of hunches, is a much neglected and essential feature of productive thinking not only in formal academic discipline but also in everyday life" (pp. 13-14). Intuitive thinking is a necessary condition for problem solving activities. It requires one to have a broad knowledge base. As a matter of fact, a learning environment that only allows individuals to learn skills in isolation will have no room for intuition. I totally agree with Bruner (1977) that "the shrewd guess, the fertile hypothesis, the courageous leap to a tentative conclusion--these are the most valuable coin of the thinking at work, whatever his line of work" (p. 14).

Learning higher cognitive skills--inferences, generalizations, and math problem solving--students will also learn to make use of strategic planning, inductive reasoning, and deductive reasoning. Learning higher-order thinking skills involves the active exploration, discovery, assimilation, and accommodation of the environment in which children may find themselves (Shade, 1985). It is pertinent to note that in the process of interacting with the environment, most of the knowledge a child gains is very conseq ntial. Connell (1989) argues that consequential knowledge does in no way include rote memorization, whether it involves the process of determining what important information is to be learned and incorporating the information into one's already existing schema.

CAI programs are characterized with an ideal environment that will make the acquisition of higher-order thinking skills possible. According to Mandinach, Linn, and Fisher (1983), the following characteristics of CAI makes the acquisition of higher-order thinking skills possible--interactiveness, complexity, precision, consistency, challenge, and provision for multiple solutions. Also, open-ended and discovery oriented CAI programs tend to be ideal for learning higher-order thinking skills. The characteristics of CAI environment help every individual to acquire higher-order thinking skills. However, students acquire them at different degrees because of their different cognitive styles and level of aptitude (Mandinach et al., 1983).

Information processing theory, or model as many would like to call it, studies the flow of information through the cognitive system which begins with the input of information into human information processing system and ends with an output--a decision, or in most cases information stored in long-term memory (Miller, 1989). This theory is interested in how humans transform input into output, that is, what mental processes does a young child apply to a particular information which will result in transformation, manipulation, and the use of the information (Miller, 1989)? In order to look at the mental processes, the theory tends to focus on how a child encodes information and stores them in a particular situation or task.

The theory holds that information processing system or unit in humans has sensory registers called short-term memory and long-term memories/stores. Information reaching the sensory modalities are retained for several seconds (Miller, 1989). According to Miller (1989), "children's sensory registers appear to have as great a capacity as those of adults. However, children form sensory representations more slowly than do adults" (p. 282). Once a child receives information, it is stored in the short-term memory to be used immediately or to be stored in the long-term memory before it is lost. The short-term memory has a limited capacity to store information while the long-term memory has a larger capacity.

Information processing theory holds that attention, memory, and thinking are important variables in the process of information. It believes that children are active learners and contends that its self-correcting feedback should not be viewed as reinforcement or punishment to manage or regulate response, but as an acquisition (Miller, 1989).

It is apparent that this study is partly based on information processing theory. This is because higher-order thinking skills--inferences, generalizations, and math problem solving--require not only good attention and memory, but also require the ability to filter out unnecessary information, to think deeply in order to activate relevant information stored in the long-term memory, and to self-correct. In problem solving, self-correction feedback is very important because it provides children with the opportunity to try out various strategies in an attempt to solve problems. According to Christensen and Tennyson (1988) and Tennyson (1988) the thinking skills associated with integration and differentiation and cognitive process of creating knowledge result from the retrieval processes.

Historical Overview of CAI

In the late 1950s the noble idea of computer-assisted instruction (CAI) was realized with the United States, Japan, and Great Britain contributing immensely to the field. However, most of the work in the field was completed in Great Britain and the United States (Kaiser, 1985). After a while many European countries and some Third World countries became interested and later developed their own coursework or used the programs already developed by Great Britain and the United States.

The CAI programs developed in the late 1950s were influenced by the behaviorist theories (Yazdani, 1987). The prevailing theory during this period was the behaviorist theory which believed that in order to increase a desired behavior, the occurrence of an operant must be followed by the presentation of a reinforcing stimulus (Yazdani, 1987). As a result of this prevailing theory, CAI programs in the 50s were designed to output a frame of text for students to respond to based on their prior knowledge or by trial and error (Yazdani, 1987). After students' responses, the computer informed the students of their correct or incorrect response. Based on the theory ingrained in these CAI programs, the students were allowed to work at their own pace and got immediate reward for correct responses. Such CAI programs are still being used in many classrooms today.

The 1960s saw most of the CAI programs designed to use students' response or answer to control the next material that will be shown on the screen (Yazdani, 1987). Yazdani (1987) called the type of CAI programs designed during this period "branching programs." These programs were designed to help students learn concepts at their appropriate level of difficulty since the concepts the students would work on would be determined by the knowledge the students possess.

In the early 1970s Great Britain and the United States witnessed a simultaneous major breakthrough in CAI. A 5-year CAI project at the University of Leeds in 1972 called National Development Program in Computer Assisted Learning (NDPCAL) was funded by the British government (Kaiser, 1985). In the United States the National Science Foundation funded the establishment of a consortium called CONDUIT consisting of the Universities of Texas, North Carolina, Oregon, Iowa, and Dartmouth University (Kaiser, 1985). Kaiser reported that the primary purpose of the consortium was to establish a clearinghouse whose job was to acquire, evaluate, and distribute quality CAI programs. Many other CAI funded projects followed later (Kaiser, 1985).

CAI programs witnessed high levels of sophistication in their design in the 1970s and 1980s (Yazdani, 1987). This was primarily because of the availability of research funds for CAI programs and the interest the field had generated. Currently, discovery and simulation modes are inherent in some CAI programs.

CAI in Educational Settings

Several studies in computer-assisted instruction (CAI) in a variety of educational settings have claimed its effectiveness in instruction and learning (Casteel, 1989; Bitter, 1987; Clark, 1985; Claver, Watson, Brinkley, & Penny, 1990; Chang & Osguthorpe, 1990; Cleary, Mayes, & Packham, 1976; Clements, 1991; Drexler, Harvey, & Kell, 1990; Golub, 1984; Gourgey, 1987; Koohang & Stepp, 1984; Mevarech, 1985; Moore, 1988; Sheingold, Kane, & Endreweit, 1983; Viteli, 1989; Woodill, 1987).

Golub (1984) points out that CAI can help students become effective and efficient in solving problems. Koohang and Stepp (1984) believed that CAI might be the answer to the full implementation of Mastery Learning System in the public schools. Mastery Learning

System (MLS) is a learning system first developed by Carrol in 1963 and was later transformed to a working model by Bloom in 1968 (Koohang & Stepp, 1984). MLS holds that gains in school learning is a function of

$$\frac{A + B}{C + D + E};$$

i.e., gains in school learning = $\frac{(A + B)}{(C + D + E)}$

where A represents perseverance, B represents opportunity to learn, C is aptitude, and D and E are quality of instruction respectively (Koohang & Stepp, 1984). Lack of time has been the major drawback of MLS. It is believed, according to MLS, that a student who has little time for a subject coupled with possessing little ability in the subject, will not succeed in learning (Koohang & Stepp, 1984). Koohang and Stepp (1984) point out that the problem of time inherent in MLS has been eliminated by the CAI. This is because CAI allows students to work at their own pace.

Cleary, Mayes, and Packham (1976) and Cuffaro (1984) found CAI has the ability to provide students with individualized instruction, immediate feedback, increased level of interaction, tutorial and dialogue systems, and the opportunity to proceed at their own pace. In reviewing 32 studies, Viteli (1989) found that drill and practice, tutoring, simulation, and problem solving are more effective with CAI than with traditional approach. He contends that students learn in less time through CAI than through traditional approach.

Drexler, Harvey, and Kell (1990) found in their study of kindergarten, first and second grades, and special program classrooms in some western, midwestern, and southern schools in the United States using Apple Learning Series--Early Language (ALS-EL), a computer-based language arts instructional program, to be effective in increasing students' motivation. Sheingold, Kane, and Endreweit (1983) also found increased motivation among students using CAI in Salerno, Granite, and Greenview school systems in 1980/81. However, they found minimal learning outcomes in math among students using CAI. Also, Krendel and Lieberman (1988) found in their review of recent research on CAI that it enhances motivation.

In a meta-analysis of 32 studies, Kulik, Kulik, and Bangert-Drowns (1985) found that CAI has positive effects on the achievement of elementary school students. In an attempt to investigate the effectiveness of CAI in math, Watkins (1986) studied a complete first grade class of an elementary school in a suburban southwestern part of the country and found that the group that used CAI in math achieved better than the other. The same was true of the study that examined the effectiveness of CAI in math among sixth-grade students (Ferrell, 1986).

Bass, Ries, and Sharpe (1986) found that fourth-grade students who received CAI in math and reading performed better in those areas than those who did not receive CAI in math and reading. However, when comparing fifth- and sixth-grade CAI groups with control groups, there were mixed results. In 16 literature reviews of the effectiveness of CAI, Niemiec and Walberg (1987) concluded that CAI increased students' learning outcomes by a moderate .42 standard deviation. This suggests that in the light of cost effectiveness a traditional approach is better than CAI (Niemiec & Walberg, 1987).

Inferences, Generalizations, and Math Problem Solving

It is undoubtedly obvious that our teaching focus has been on rote memorization of rules and facts rather than on engaging students in decision making and problem solving relating to their everyday life. Mead (1969) concludes that irrespective of the dynamic nature of our world, our educational system adamantly remains unchanged, holding on to the notion of vertical transmission of knowledge which has outlived its place. In place of vertical transmission of knowledge Mead (1969) suggested a lateral transmission of knowledge whereby knowledge will be shared among informed and uninformed. That, too, has no place in today's educational environment. Students need to interact with their world in the process of constructing knowledge. As a result of this, teachers will be at their best when they facilitate students' knowledge rather than when they try to transmit knowledge. One major problem in education is our inability to adapt teaching to the way our children think (DeVries & Kohlberg, 1987). Cordel (1991) believes that quality of learning is enhanced when instructional strategies are matched to students' learning style.

The National Teacher Education Task Force, among others, is calling for the development of higher-order thinking strategies-based curriculum (Tennyson, 1989). However, it is impractical to implement such a curriculum if educators still believe in the transmission of knowledge coupled with lack of full utilization of CAI. According to Connell (1989) and Solomon (1986) CAI has the much needed flexibility necessary to create learning environments that will enhance children's lives and at the same time provide the opportunity to improve the content, quality, and the delivery of education. Bruner (1969) supports the undeniable importance of CAI in teaching higher-order skills by saying that "man's use of mind is dependent upon his ability to develop and use 'tools' or 'instruments' or 'technologies' that make it possible for him to express and amplify his powers" (p. 13). In order to clarify what he meant by those terms Bruner (1969) went on to say that "I know that the terms 'tool' and 'technology' and even 'instrument' offend when one speaks of man as dependent upon them for the realization of his humanity. For these words denote 'hardware,' and it is mostly 'software' that I have in mind--skills that are tools" (p. 13).

Mathematics problem solving had been one of the major weaknesses in our students' mathematics achievement (Anand & Ross, 1987). It appears that most of our students find it difficult to solve mathematics word problems because they have been taught math in isolation. Bennett (1986) argues that "what is most lacking in elementary mathematics is a sense of relationship between the formal skills children learn and their application to real problems. He concluded that as late as eighth grade, the teaching of math is "predominantly formal with an emphasis on rules, formulas, and computational skills as opposed to being informal, intuitive, and exploratory" (p. 12). He goes on to say that our "children in the elementary years need not only the basic computing skills, but need also to learn how to select the right strategies to solve complicated problems. Our schools face a major challenge in imparting these crucial math skills and problem solving strategies" (p. 12). That is, the examples of the math problem solving they encounter in the classroom are not contextually relevant. In addition, the examples of math problem solving we give in the classrooms, and the method with which we present them, are success-oriented which entirely focus on goals (Chaille & Littman, 1985). In contrast to success-oriented problem solving, they advocated for a theory-oriented problem solving that accounts for experience which focuses on means instead of goals or end results. A theory-oriented problem solving focuses on the processes, relationships, and principles (Chaille & Littman, 1985).

In studying fifth- and sixth-grade students Anand and Ross (1987), Ross and Anand (1987), and Ross, Anand, and Morrison (1988) found that students who practiced with CAI personalized math problem solving achieved better in math problem solving made contextually relevant.

However, Viteli (1989) found in his study of fifth-grade students' ability to do word math problems in a private school in Davie, Florida, that CAI is not more effective than teachers teaching word math problems. He found that the computer-taught groups and teacher-taught groups performed equally in word math problems.

Computers are highly capable of providing instructions in math problem solving that are characterized with contextually relevant materials and information. Papert (1980) contends that computers can be used to concretize and personalize information. Chaille and Littman (1985) agree with Papert by saying that increased use of computers has provided students with the experiences necessary for them to engage in both concrete and abstract thinking required in math problem solving. The provision of experiences being talked about here is made possible by computer simulations. Willis et al. (1987) define simulations as "models or descriptors of events and conditions" (p. 34). According to Willis et al. (1987), computer simulation helps one to model or duplicate aspects of the real world in the classroom. Goodyear (1991) holds that computer simulation provides access to "learning experiences which would otherwise be prohibitively expensive, time-consuming, intellectually demanding, dangerous, or ethically suspect" (p. 99).

One of the characteristics of many CAI programs is that it provides the learner with the opportunity to be in control. The major advantage of learner control is the provision of individualized instruction (Kinzie, 1990). Behaviorist-based instruction is highly structured, with teacher-directed or computer-directed, isolated smaller steps, more practice, and an extensive feedback (Kinzie, 1990). This type of teaching is dominant in our public schools where the inherent learning outcome is measured with an achievement test similar to the instruction (Kinzie, 1990). On the other hand, cognitively-designed instruction, whether it is CAI programs or not, presents information in larger chunks and is more effective in providing students opportunities to engage in a high level learning by constructing larger-scale knowledge structures (Kinzie, 1990). Kinzie (1990) points out that learning outcomes of learner control cognitive instruction is measured with a long-range achievement and continued motivation to learn.

Wishart (1990) notes that "the most important reason why the computer constitutes such a powerful pedagogical tool is that its interactivity gives children a sense of control" (p. 146).

According to Pogrow (1987, 1988) the Higher Order Thinking Skills (HOTS) program had been found effective in helping students develop metacognition, inference, and decontextualization skills coupled with the ability to combine and synthesize information by using dramatic techniques. It is pertinent to note that metacognition and decontectualization skills are primarily very essential in enhancing problem solving skills. While metacognition entails the ability to develop articulate strategies and test their reasonableness or impact on problem solving situations, decontextualization is an ability to apply information from one context to another or linking related information (Pogrow, 1987).

The HOTS program is being used primarily by Chapter 1 programs in grades three through six. According to Pogrow (1987), more gains were made by the students using the program in both thinking skills and social interaction during the first year. In addition to this, the schools that use the program generated gains from 15 percentile points to 25 percentile points on standardized tests in reading during the first year. Also their math scores on standardized tests showed significant gains.

In their study of 36 4-year-old children's critical thinking skills, Riding and Powell (1985) found that the group of children who received 16 computer-presented problem solving activities showed a significantly greater gain on their Raven's Coloured Progressive Matrices posttest scores than did the control group. This group of children worked under a male experimenter. In order to determine if their study could pass the test of generalizability, Riding and Powell (1986) replicated their study a year later with a different experimenter coupled with a different sample of subjects. Utilizing 60 4-year-old children and providing the experimental group of 30 children with 16 computer-oriented activities designed to facilitate critical thinking for 45 minutes per week for 6 weeks, their findings were no different from their previous study. The experimental group made a significantly greater improvement between their pretest and posttest scores on Raven's Matrices than did the control group (Riding & Powell, 1986). The results of the two studies suggest that young children are not only capable of working with the computer, but can, as well, think with it. This has supported the notion of some researchers that young children should not wait until they reach the concrete operational stage before working with the computer (Shade & Watson, 1990).

According to Evans (1986) young children can benefit from computers because their thinking and problem solving skills can be enhanced by pattern recognition, memory, logic, and problem solving oriented computer softwares. Since young children are curious, they will be motivated to explore, manipulate, and interface with computers and the software programs.

In studying 25 second-grade students from a public elementary school in the Spring of 1983, whose curriculum was supplemented with Logo computer programming experience that lasted for 3 months, Rieber (1986) found that the treatment group did better in problem solving than the control group as measured by ITBS.

In a 2-year projects study of the effectiveness of computer instruction in math and reading involving about 700 students ranging in age from 3-11 years, Harckham (1986) found that no significant effects relating to the achievement, problem solving ability, and the general cognitive ability of handicapped children were produced by the computer instructional software and Logo.

Martin (1990) studied summer camp computer students who were entering second grade. These students were practicing problem solving skills in the EZ Logo environment. From the results of pretest and posttest, the study could not confirm any gains made by these students in higher-order thinking skills.

Robinson (1984) holds that children of all ages can benefit from computer language such as Logo. The author believes that Logo provides children with the opportunity to freely direct their own learning by engaging in logical thinking and planning in an effort to solve problems. According to Robinson (1984), "one of the most powerful outcomes is that students are able to analyze and develop their thinking and problem solving skills as well as develop specific debugging strategies. After hours of open-ended explorations, children will set specific goals and work very hard to achieve them, and the scenario is repeated at every grade level" (p. 1).

Burns and Hagerman (1989) found that the experimental group of six girls and five boys out of 22 third-grade students in a class from a public school in South Hadley, Massachussetts, who received Logo and Delta Drawing activities for $4\frac{1}{2}$ months showed a greater increase in

Intellectual Achievement Responsibility Scale than the control group. However, the experimental group did not do better than the control group in performance on an attention task after noncontingent success and failure feedback. In this study, Burns and Hagerman (1989) concluded that "previous studies of Logo effects have yielded significant gains in children's problem solving, spatial cognition, creativity, and generalized thinking skills. However, substantial body of research has not supported these gains leading to a mixed picture concerning Logo and children's thinking" (p. 209). The authors believe that the difficulty in selecting an appropriate control group accounts for the contradictory findings in the computer effects literature in general and Logo effects literature in particular.

Burns and Hagerman (1989) went further to conclude that "the Logo effects literature is often presented in the theoretical vacuum. Researchers who do attempt to theoretically find significant effects of Logo on children's thinking do so in a most superficial manner. Piaget's ideas of developing constructs and allowing formal operations by concrete thinkers have been used so generally that no further theoretical developments are possible. An exception to this has been recently provided by Clements who has framed particular Logo effects within Sternberg's theory of cognition. Within Sternberg's model, the mechanisms of cognitive development consist of interactions between three major (and elementary) information-processing components: Metacomponents, performance components, and knowledge acquisition components. Logo experiences are proposed by Clement to affect the automatization and interaction of these components by requiring children to analyze their own thinking and make explicit and concrete these components of problem solving" (pp. 209-210).

Jussel (1990) found in a pilot study that computers can be successfully used to help fifth- and sixth-grade students enhance or develop their problem solving skills. Computers also offer young children the opportunity to learn by doing various tasks in a way similar to the manner in which an adult would do them (Clements, 1985). This is especially true with computer softwares oriented with cognitive developmental principles. In a study of 134 students (19 preschoolers, 82 kindergartners, and 34 first-grade students), Grover (1986) found that the learning of children utilizing cognitive developmentally-oriented softwares was enhanced. The cognitive developmental software programs used in the study are designed to provide children with more than one opportunity to succeed, including nonthreatening reinforcements, are more user-friendly, and are more open-ended in the type of questions they contain. According to Forcheri and Molfino (1991), various research "experiments have demonstrated that different kinds of mental activities must be brought into action in order to acquire problem solving abilities: observing, imitating, generalizing, discovering, making mistakes, correction, and so on" (p. 143).

In a study of the effects of computer assisted instruction on the cognitive ability gain of the third-, fourth-, and fifth-grade students in reading and math, Merrell (1984) found that students who received CAI in addition to their regular classroom instruction scored higher in math than others, but they did not score better than other students in reading. Hirsch (1986), in his study of the effectiveness of using computer-assisted instruction to teach fifth-grade students problem solving, concluded that there was a statistical significant difference between the experimental group and the control group in their problem solving abilities.

Lehrer and Randle (1987) in their experimental study of 39 first-grade students in a school in New York serving predominantly low SES students to determine the available softwares on problem solving, metacognition, and composition, found that the experimental group's problem solving skills coupled with components of metacognition appeared to be enhanced. The research failed to replicate Clement's (1987) study which reported increases in metacognition and problem solving when students in either Logo environment or commercially available interactive software environment were contrasted with the control group. Perkins (1987) studies the impact of computer-assisted instruction on fourth- and seventh-grade students' attitude toward mathematics and knowledge of 10 low scoring objectives in mathematics in the Michigan Educational Assessment Program (MEAP). She found that while CAI influenced the mathematics achievement of the experimental mathematics group significantly and positively, it did not significantly influence their attitude toward mathematics and computers. Cathcart (1990) studies 43 fifth-grade students from two schools in a middle to upper-middle class school district in Canada and found that his experimental group of 25 students, which had instructional experiences in Logo for 14 weeks, scored higher than the control group on the posttest in divergent thinking which was assessed with Torrance Tests of Creative Thinking-Figural Test.

Lee (1990) found in her meta-analysis of the effects of computer-assisted instruction and computer programming that they do have positive effects on elementary students' attitude toward computer, achievement, and problem solving skills. In another meta-analysis of computer-assisted instruction and computer programming on cognitive performance of students, Liao (1990) concluded that the use of computer programming and computer-assisted instruction can positively enhance the cognitive performance of students.

Webster (1990) found in her study of 125 black fifth-grade students enrolled in math classes in five elementary schools in a rural school district in Mississippi that the group that used computer-assisted instruction has a more positive attitude toward computers and math than does the control group. Cannady (1990) found in his study to determine the relative effects of computer-assisted instruction, cooperative learning, and teacher-directed instruction on improving math performance of low-achieving sixth-grade students that there was no significant difference between the three groups in their performance on math concept, math computations, and math problem solving on the ITBS. Ninety-nine students were involved and were randomly assigned to one of the three instructional methods for a 5-week summer remediation (Cannady, 1990).

Summary

Though the review of literature did not reveal any study that deals with using computers to teach specifically inferences, generalizations, and math problem solving, the evidence from the cited studies showed that computer technology is an effective tool in instruction and learning in all grade levels. However, the technology is not a panacea to most of our educational problems. Some research studies still suggest that computers are no more effective in enhancing students' learning and higher-order cognitive skills than are classroom instructions without computers. The studies that utilize Logo computer programming or a similar software reported little or no student gains in higher-order cognitive skills. These research studies did not utilize varieties of interactive computer softwares in addition to Logo.

If our students are going to be competent in higher-order cognitive skills, it is obviously imperative that not only we integrate computer technology into our educational programs--across curriculum--but we must provide varieties of developmentally appropriate interactive computer softwares. In the proceeding chapter the methodology for investigating and assessing the purpose of this study will be presented.

CHAPTER III

METHODOLOGY

The primary purpose of this study was to investigate and assess the effectiveness of computer-assisted instruction (CAI) with varieties of interactive computer software in teaching higher-order thinking skills--inferences, generalizations, and math problem solving--in the primary grades (grades one and two). Secondly, this study investigated the effect of CAI on students' self-concept, attitude toward school, attitude toward computers, and skills they could learn with computers, including the total score on student attitude measure.

To address the purpose of this study, research questions were asked and the following hypotheses were stated:

Ho 1: There will be no statistically significant difference in Iowa Test of Basic Skills (ITBS) scores for inferences, generalizations, and math problem solving subtests, including grade equivalent scores in reading and math, between students who received CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months and those students who did not receive CAI.

Ho 2: There will be no statistically significant difference in overall academic achievement measured by the ITBS composite scores between experimental and control groups or grades one and two.

Ho 3: there will be no statistically significant difference between the experimental and control groups or grades one and two in their self-concept, attitude toward school, attitude toward computers, and skills or things they could do with computers.

Ho 4: There will be no statistically significant difference in inferences subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.

Ho 5: There will be no statistically significant difference in generalizations subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.

Ho 6: There will be no statistically significant difference in math problem solving subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.

Design

This study was a comparative experimental design utilizing pre- and posttest scores on ITBS. The 1991 ITBS scores served as a pretest while the 1992 ITBS scores served as the posttest. This study utilized only the 1992 ITBS scores because the 1991 ITBS test for those presently in grade one was limited in scope. In addition to this, the scores of the Student Attitude Measure were utilized. This instrument was developed by Dr. David A. Gilman at Indiana State University for use in the evaluation of instructional technology programs.

Subjects

The study was conducted at an inner-city elementary school in Dallas that has a population of about 600 students from pre-kindergarten to sixth grade. Four classes of first and second grade students were included in the study. A total of 64 first-grade students and 77 second-grade students were utilized. Out of 64 first-grade students in the study, there were 38 boys and 26 girls. The ethnic breakdown of this sample was 45 Blacks, 3 Whites, and 16 Hispanics. Out of 77 second-grade students in the study, there were 35 boys and 42 girls; 62 Blacks, 1 White, and 14 Hispanics.

The experimental and control groups consisted of two classes of each grade level. The assignment of classes to the experimental and control groups was done randomly. There were 39 sample of first-grade students in the experimental group. The control group of the first graders consisted of 25 students. Out of 39 subjects in the experimental groups, there were 20 boys and 19 girls; 23 Blacks, 1 White, and 15 Hispanics. The control group was made up of 18 boys and 7 girls; 22 Blacks, 2 Whites, and 1 Hispanic. Out of 77 second graders in the study, 40 were in the experimental group and 37 were in the control group. There were 22 boys and 18 girls in the experimental group. The experimental group was also made up of 36 Blacks, 1 White, and 3 Hispanics. Out of 37 subjects in the control group, there were 13 boys and 24 girls; 26 Blacks, no White, and 11 Hispanics. This study lost 10 students due to transfers. As a result, it ended up with a total of 131 subjects.

Experimental Treatments

Treatment for the experimental group consisted of CAI with varieties of interactive computer software in inferences, generalizations, and math problem solving. Prior to using the computer software design to teach higher-order thinking skills, both experimental and control groups received pre-keyboarding instructions 30 minutes a day for 2 days.

Apple computers 11GS and 11E were used. Commercially available interactive computer software in inferences, generalizations, and problem solving were used to teach the experimental group.

The experimental group received their treatments 30 minutes a week for 4 months. They received the treatments in addition to their regular class instructions in a computer situation under the supervision of a trained computer specialist. In studying seventh- and eighth-grade students' interaction with computer, Trowbridge (1987) found that computers are more effective when students are in groups of two or three than when working alone. Watson (1991) found the same to be true.

Therefore, the students in this study worked in groups of two.

Instrumentation

In assessing or determining whether the subjects increased their higher-order thinking skills, the 1991 and 1992 ITBS scores on inferences, generalizations, math problem solving were utilized. Scores on students' attitude measures were used to determine if computers affected students' attitude toward school, attitude toward computers, self-concept, and the skills or things they could do with computers.

The Student Attitude Measure was developed by Dr. David A. Gilman at Indiana State University in the 1987/88 school year for the evaluation of an instructional technology program for the Metropolitan School District of Mount Vernon, Indiana. The student attitude instrument is divided up into four subtests and each subtest consists of Likert Bipolar Attitude Inventory items. Table 1 shows the pre- and posttests reliabilities of the subtests.

Table 1

Pretest and Posttest Reliabilities of Student Attitude Measure

Items	Subtest	Reliabilities	
		Pretest	Posttest
1 - 20	Self-concept	.80	.86
21 - 30	About My School	.87	.90
31 - 40	About Computers	.85	.90
41 - 54	What I Can Do With Computers	.80	.94
1 - 54	Total	.90	.94

Source: Gilman, D. A., 1991.

Data Collection

The subjects' 1991 ITBS scores on inferences, generalizations, and math problem solving were collected and analyzed. After the experiment, their 1992 ITBS scores on the same subtests were collected for analysis. This study intended for the classroom teachers to administer the students' attitude measure to all the subjects in the study prior to the inception of the treatments. Few of the teachers did so. For those teachers who administered the instrument to their students, they did not follow the direction that required them to read each item to the subjects. As a result of this, the subjects did not complete the instrument fully. Based on this problem, this study did not utilize the pretest scores of the students' attitude measure. At the end of the experiment, the students' attitude measure was administered to the subjects by their respective teachers who followed the administration direction. The administration of the instrument took approximately 30 minutes to an hour. There was a make-up for those students who were absent on the administration day. The results were collected and analyzed.

Statistical Data Analysis

Series of one-way and two-way analysis of variance (ANOVA) were utilized to test the hypotheses. All hypotheses were tested at .05 alpha level. The summaries and results of the analyses will be found in the proceeding chapters.

Summary

After all the procedures for the research were completed, the data collected was analyzed by SPSS-X package on the computer main frame at Texas Woman's University. The statistical procedures used in testing the hypotheses are described in Chapter IV. Also the reports of statistical findings are reported in Chapter IV.

CHAPTER IV

DATA ANALYSIS AND RESULTS

The main thrust of this study was to determine whether students who received CAI with varieties of interactive software programs performed differently than did students in the control group on ITBS scores in inferences, generalizations, and math problem solving. In other words this study attempted to assess the effects of CAI with varieties of interactive software programs on primary students' higher-order thinking skills, including their self-concept, attitude toward school, attitude toward computers, and what they could do with computers. In order to evaluate the effectiveness of CAI, this study tried to determine the differences among groups of students differentiated by reception or failure to receive CAI varieties of interactive software programs designed to teach higher-order thinking skills for a period of 4 months and grade level.

The data collected for this study were analyzed utilizing SPSS-X on the main frame computer at Texas Woman's University. In reporting the findings of this study, the data for each of the six hypotheses were discussed separately.

Hypothesis 1

There will be no statistically significant difference in ITBS scores for inferences, generalizations, and math problem solving subtests, including grade equivalent scores in reading and math, between students who received CAI with varieties of interactive software designed to teach higher-order thinking skills for a period of 4 months and those students who did not receive CAI.

Findings

Hypothesis 1 was tested by analysis of variance (ANOVA) procedure utilizing posttest scores on ITBS subtests of inferences, generalization, math problem solving and grade equivalent scores in reading and math as the dependent variables. Data parameters and results of the analysis are presented separately for each dependent variable.

Inferences. It is a cognitive ability to establish cause and effect, draw conclusions, synthesize and infer traits, feelings, and motives of characters in a selection or paragraph. Table 2 displays the results of ANOVA of inferences posttest scores.

Table 2

Result of Analysis of Variance (ANOVA) of Inferences Posttest Scores by Study Groups

A. Data Parameters

Group	N	Mean	SD
CAI	64	45.2	17.6
Non-CAI	58	45.9	19.0

B. ANOVA Summary Table of Inferences Posttest Scores

Source of Variations	SS	DF	MS	F	P
Between Groups	16.32	1	16.32	.0487	.825
Within Groups	40226.03	120	335.21		

The results indicate that whether students received treatments or not did not have a statistically significant effect on their ability to make inferences. Reception of CAI with varieties of interactive software programs did not have any significant effect on the inferences scores.

Generalizations. This is a cognitive ability to evaluate the authors' viewpoint, attitude, motive, and mood. Generalizations are cognitive abilities to make evaluative meanings. Table 3 displays the results of ANOVA of generalizations posttest scores.

Table 3

Results of ANOVA of Generalizations Posttest Scores by Study Group

A. Data Parameters

Group	N	Mean	SD
CAI	64	28.26	21.59
Non-CAI	58	21.70	20.97

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Between Groups	1308.84	1	1308.84	2.8850	.092
within Groups	54440.50	120	453.67		

The results show that the ability to make generalizations based on reading selections by students did not statistically significantly depend on whether or not they received CAI with varieties of interactive software programs. The mean difference tended to approach significance, with CAI group having a higher generalizations mean.

Math Problem Solving. This is a cognitive ability to analyze and solve perplexing math problems stated in words. It may comprise of single or multiple steps involving several applications. Table 4 shows the results of ANOVA of math problem solving.

Table 4

Results of ANOVA of Math Problem Solving Posttest Scores by Study Group

A. Data Parameters

Group	N	Mean	SD
CAI	64	54.57	23.54
Non-CAI	58	51.11	18.54

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Between Groups	1614.766	1	1614.766	3.553	.061
Within Groups	5433.626	120	454.446		

The results indicate that variations in the math problem solving scores were not affected by the treatment.

The difference approaches statistical significance, with the CAI group having a higher math problem solving mean.

Grade Equivalent Scores in Reading. This shows the grade level at which students are performing in reading. Table 5 displays the results of ANOVA of grade equivalent posttest scores.

Table 5

Results of ANOVA of Grade Equivalent Posttest Scores in Reading By Group

A. Data Parameters

Group	N	Mean	SD
CAI	62	1.62	.709
Non-CAI	57	1.51	.745

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Between Groups	.3808	1	.3808	.7207	.397
Within Groups	61.823	1171	.5284		

The results show that the treatment did not affect the grade level which students performed in reading. There was no statistically significant difference between group means. Though the CAI group had a higher mean, it was not significant.

Grade Equivalent Scores in Math. This shows the grade level at which students are performing in math. Table 6 shows results of ANOVA of grade equivalent scores in math.

Table 6

Results of ANOVA of Grade Equivalent Posttest Scores in Math by Study Group

A. *Data Parameter*

Group	N	Mean	SD
CAI	62	2.116	.641
Non-CAI	54	2.048	.843

B. *ANOVA Table*

Source of Variations	SS	DF	MS	F	P
Between Groups	.133	1	.133	.242	.623
Within Groups	62.778	114	.551		

The results indicate that CAI did not affect the grade level at which students performed in math. That is, there was no statistically significant difference between the CAI and the Non-CAI groups.

Decision. Null Hypothesis 1 was not rejected. It was concluded that the performance of CAI and Non-CAI groups in inferences, generalizations, and math problem solving, including grade level equivalent scores in reading and math, was not significantly different,, when grade level differences were not taken into consideration.

Hypothesis 2

There will be no statistically significant difference in overall academic achievement measured by the ITBS composite scores between experimental and control groups or grades one and two.

Findings

Hypothesis 2 was tested and analyzed by TWO-WAY ANOVA procedure utilizing posttest scores on ITBS composite as a dependent variable. Data parameters and results of the analysis are presented for the dependent variable.

Composite scores show the grade level at which students performed taking into account all subtest areas. Table 7 displays the results of ANOVA of composite posttest scores.

Table 7

Results of ANOVA of Composite Posttest Scores by Study Group and Grade Level

A. Data Parameters

Group	Grade	Mean	N
CAI	1	1.40	31
CAI	2	2.21	31
CAI	Total	180	62
Non-CAI	1	1.32	24
Non-CAI	2	2.12	28
Non-CAI	Total	1.75	52
Grade Total	1	1.36	55
Grade Total	2	2.17	59
All Subjects		1.78	114

(table continues)

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Study Group Main Effect	.193	1	.193	.616	.434
Grade Level Main Effect	18.531	1	18.53	59.103	.001*
Group by Grade Interaction	.000	1	.000	.001	.981
Explained	18.606	3	6.202		
Residual	34.489	110	.314		
Total	53.095	113	.470		

*$p < .05$

The ANOVA results indicate that variations in the composite score was significantly affected by grade level. Also the results show that whether or not students had received CAI did not significantly affect achievement on ITBS.

Decision. Null hypothesis 2 was rejected. It was concluded that there was a significant difference in overall academic achievement between grade one and grade two groups. It should be noted that CAI or lack of CAI did not significantly affect overall academic achievement.

Hypothesis 3

There will be no statistically significant difference between the experimental and control groups or grades one and two in their self-concept, attitude toward school, attitude toward computers, and skills or things they could do with computers.

Findings

Hypothesis 3 was tested and analyzed by ANOVA procedure utilizing posttest scores on self-concept, attitude toward school, attitude toward computers, and skills or things students could do with computers as the dependent variable.

Self-concept. Self-concept is a total knowledge of self. It includes attitudes, feelings, and knowledge of abilities, skills, appearance, and social acceptability. Table 8 shows the results of ANOVA of self-concept scores.

Table 8

Results of ANOVA of Self-concept Scores by Study Group and Grade Level

A. Data Parameters

Group	Grade	Mean	N
CAI	1	53.50	34
CAI	2	45.91	35
CAI	Total	49.65	69
Non-CAI	1	52.52	27
Non-CAI	2	45.29	35
Non-CAI	Total	48.44	62
Grade Total	1	53.07	61
Grade Total	2	45.60	70
All Subjects		49.08	131

(table continues)

B. ANOVA Table

Source of Variation	SS	DF	MS	F	P
Study Group Main Effect	20.404	1	20.404	.382	.537
Grade Level Main Effect	1788.76	1	1788.76	33.530	.001*
Study Group by Grade Interaction	1.008	1	1.008	.019	.891
Explained	1838.11	3	612.70		
Residual	6775.12	127	53.34		
Total	8613.23	130	66.25		

*$p < .05$

The results show that variations in self-concept score was significantly affected by grade level, with second graders scoring lower than first graders. Whether or not students had received CAI was not significantly related to self-concept.

Attitude toward School. This shows if students like school or not. It tries also to get information from students regarding why they like or not like school. Table 9 displays the results of ANOVA of attitude toward school scores.

Table 9

Results of ANOVA of Attitude Toward School Scores by Study Group and Grade Level

A. Data Parameters

Group	Grade	Mean	N
CAI	1	27.82	34
CAI	2	24.03	35
CAI	Total	25.90	69
Non-CAI	1	24.04	27
Non-CAI	2	21.69	35
Non-CAI	Total	22.71	62
Grand Total	1	26.15	61
Grade Total	2	22.86	70
All Subjects		24.39	131

(table continues)

B. ANOVA Table

Source of Variation	SS	DF	MS	F	P
Study Group Main Effect	294.96	1	294.96	14.13	.001*
Grade Level Main Effect	315.78	1	315.78	15.13	.001*
Study Group By Grade Interaction	16.86	1	16.86	.808	.370
Explained	664.73	3	221.58		
Residual	2650.42	127	20.87		
Total	3315.15	130	25.50		

*$p < .05$

The results show that variations in attitude toward school scores were significantly affected by both reception of CAI and grade level. In other words both reception of CAI and grade level were significantly related to the students' score on attitude toward school. Those students who received CAI had a better attitude toward school than those who did not receive CAI. Also, first graders had a better attitude toward school than second graders.

Attitude toward Computers. This tends to show how students feel about computers. It also indicates the students' feelings or knowledge of whether or not computers could help them in doing their classwork.

The results of ANOVA of attitude toward computers scores are displayed in Table 10.

Table 10

Results of ANOVA of Attitude Toward Computers Scores by Study Group and Grade Level

A. Data Parameters

Group	Grade	Mean	N
CAI	1	28.41	34
CAI	2	25.69	35
CAI	Total	27.03	69
Non-CAI	1	25.44	27
Non-CAI	2	24.26	35
Non-CAI	Total	24.77	62
Grade Total	1	27.10	61
Grade Total	2	24.97	70
All Subjects		25.96	131

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Study Group Main Effect	149.06	1	149.06	10.48	.002*
Grade Level Main Effect	130.49	1	130.49	9.17	.003*
Study Group by Grade Interaction	19.16	1	19.16	1.35	.248
Explained	315.68	3	105.23		
Residual	1807.13	127	14.23		
Total	2122.81	130	16.33		

*$p < .05$

The results indicate that variations in the attitude toward computers scores were significantly affected by both reception of CAI and grade level. The experimental group and first graders had a better attitude toward computers than control group and second graders respectively.

Things or Skills Students Could Do With Computers. This indicates a variety of things students could do or learn with computers. The ANOVA results of this variable are displayed in Table 11.

Table 11

Results of ANOVA of Skills Students Could do with Computers Scores by Study Group and Grade Level

A. Data Parameters

Group	Grade	Mean	N
CAI	1	37.91	34
CAI	2	36.34	35
CAI	Total	37.12	69
Non-CAI	1	34.56	27
Non-CAI	2	35.03	35
Non-CAI	Total	34.82	62
Grade Total	1	36.43	61
Grade Total	2	35.69	70
All Subjects		36.03	131

(table continues)

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Study Group Main Effect	166.01	1	166.01	5.05	.026*
Grade Level Main Effect	12.13	1	12.13	.369	.545
Study Group by Grade Interaction	33.74	1	33.74	1.03	.313
Explained	217.62	3	72.54		
Residual	4174.26	127	32.87		
Total	4391.88	130	33.78		

*$p < .05$

The results indicate that reception of CAI significantly affected variations in the scores on things students could do with computers. The CAI group felt that they could do or learn more things or skills with computers than did the non-CAI group. Also, first graders felt that they could do or learn more things or skills with computers than did second graders.

Decision. Null Hypothesis 3 was rejected. It was concluded that there was a statistically significant difference between the experimental and control groups or grades one and two in their self-concept, attitude toward school attitude toward computers, and skills or things they could do with computers. There were significant grade level effects on self-concept. There were also significant grade level effects and interaction on attitude toward school and attitude toward computers. There was a significant interaction on skills or things they could do with computers.

Hypothesis 4

There will be no statistically significant difference in inferences subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.

Findings

Hypothesis 4 was tested and analyzed by ANOVA procedure utilizing mean scores on ITBS subtest of inferences as a dependent variable. Data parameters and the results of the analysis are presented for the dependent variable.

Inferences. Table 12 shows the results of ANOVA of inferences subtest scores of ITBS.

Table 12

Results of ANOVA of Inferences Posttest Scores by Study Group and Grade Level

A. Data Parameters

Group	Grade	Mean	N
CAI	1	45.02	31
CAI	2	45.30	33
CAI	Total	45.16	64
Non-CAI	1	44.00	24
Non-CAI	2	47.24	34
Non-CAI	Total	45.90	58
Grade Total	1	44.57	55
Grade Total	2	46.28	67
All Subjects		45.51	122

(table continues)

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Study Group Main Effect	11.44	1	11.44	.034	.855
Grade Level Main Effect	83.53	1	83.53	.246	.621
Study Group by Grade Interaction	65.05	1	65.05	.192	.622
Explained	164.90	3	54.98		
Residual	40077.45	118	339.64		
Total	40242.36	121	332.58		

The results of the analysis show that variations in the inferences subtest scores of ITBS were not significantly affected by the reception of CAI and grade level. Neither reception of CAI nor grade level were significantly related to students' performance in inferences.

Decision. Null hypothesis 4 was not rejected. It was concluded that whether or not students received CAI and were in first or second grade did not significantly affect their performance in inferences.

Hypothesis 5

There will be no statistically significant difference in generalizations subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.

Findings

Hypothesis 5 was tested and analyzed by ANOVA procedure utilizing mean scores on ITBS subtest of generalizations as a dependent variable. Data parameters and results of the analysis are presented for the dependent variable.

Generalizations. The results of ANOVA of generalizations posttest scores are displayed in Table 13.

Table 13

Results of ANOVA of Generalizations Posttest Scores by Study Group and Grade Level

A. Data Parameters

Group	Grade	Mean	N
CAI	1	44.48	31
CAI	2	13.03	33
CAI	Total	28.27	64
Non-CAI	1	34.96	24
Non-CAI	2	12.35	34
Non-CAI	Total	21.71	58
Grade Total	1	40.33	55
Grade Total	2	12.69	67
All Subjects		25.15	122

(table continues)

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Study Group Main Effect	649.26	1	649.26	2.44	.121
Grade Level Main Effect	22417.24	1	22417.24	84.14	.001*
Study Group by Grade Interaction	585.83	1	585.83	2.20	.141
Explained	24311.91	3	8103.97		
Residual	31437.44	118	266.42		
Total	55749.34	121	460.74		

*$p < .05$

The results indicate that variations in generalizations scores were significantly affected by grade level. Whether or not students had received CAI did not significantly affect scores on generalizations.

Decision: Null Hypothesis 5 was rejected because of the differences related to the grade level. It was concluded that variations in the generalizations posttest score was significantly affected only by grade level. It should be noted that CAI or lack of CAI did not significantly affect generalizations scores.

Hypothesis 6

There will be no statistically significant difference in math problem solving subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.

Findings

Hypothesis 6 was tested and analyzed by ANOVA procedure utilizing math problem solving as a dependent variable. Data parameters and the results of the analysis are presented for this dependent variable.

Math Problem Solving. Table 14 displays the results of ANOVA of math problem solving scores.

Table 14

Results of ANOVA of Math Problem Solving Posttest Scores by Study Group and Grade Level

A. Data Parameters

Group	Grade	Mean	N
CAI	1	72.61	31
CAI	2	37.64	33
CAI	Total	54.58	64
Non-CAI	1	60.54	24
Non-CAI	2	37.94	34
Non-CAI	Total	47.29	58
Grade Total	1	67.35	55
Grade Total	2	37.79	67
All Subjects		51.11	122

(table continues)

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Study Group Main Effect	826.56	1	826.56	3.51	.063
Grade Level Main Effect	25594.68	1	25594.68	108.67	.001*
Study Group by Grade Interaction	1146.12	1	1146.12	4.87	.029*
Explained	28355.56	3	9451.85		
Residual	27792.83	118	235.53		
Total	56148.39	121	464.04		

*$p < .05$

The results indicate that variations in the math problem solving was significantly aff cted by grade level, with grade one scoring much higher than grade two. Also, the results indicate a significant interaction. Further analysis reveals that there was a significant difference (see Table 15) in math problem solving scores between experimental and control groups in grade one.

Table 15

Results of ANOVA of Math Problem Solving Posttest Scores by Study Group in Grade One

A. Data Parameters

Group	N	Mean	SD
CAI	31	72.61	19.88
Non-CAI	24	60.54	19.95

B. ANOVA Table

Source of Variations	SS	DF	MS	F	P
Between Groups	1971.12	1	1971.12	4.97	.030*
Within Groups	21005.31	53	396.33		

*$p < .05$

Decision. Null Hypothesis 6 was rejected. It was concluded that variations in the scores on math problem solving were significantly affected by reception of CAI and grade level.

Summary

Table 16 displays the list of hypotheses tested, statistical analysis utilized, and subsequent results.

The table also shows the significant level at which some hypotheses were rejected.

Table 16

Summary of Hypotheses Tested

Hypotheses	Statistical Analysis	Results
1. There will be no statistically significant difference in ITBS scores for inferences, generalizations, and math problem solving subtests, including grade equivalent scores in reading and math, between students who received CAI with varieties of interactive computer software designed to higher-order thinking skills for a period of 4 months and those who did not receive CAI.	ANOVA	Retained

2. There will be no statistically significant difference in overall academic achievement measured by the ITBS composite scores between experimental and control groups or grades one and two.	ANOVA	Rejected, $p < .05$
3. There will be no statistically significant difference between the experimental and control group or grades one and two in their self-concept, attitude toward school, attitude toward computers, and skills or things they could do with computers.	ANOVA	Rejected, $p < .05$
4. There will be no difference in inferences subtest scores of ITBS among groups of students	ANOVA	Retained,

	differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.		
5.	There will be no statistically significant difference in generalizations subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 months.	ANOVA	Rejected, $p < .05$

6. There will be no statistically significant difference in math problem solving subtest scores of ITBS among groups of students differentiated by grade level or reception of CAI with varieties of interactive computer software designed to teach higher-order thinking skills for a period of 4 month..	ANOVA	Rejected, $p < .05$

CHAPTER V

SUMMARY, DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The growing concern that our students are deficient in higher-order thinking skills necessitates the need for a continued search for better ways to teach them inferences, generalizations, and math problem solving. With computers, we may have found a partially successful tool, but not a panacea, to teach higher-order thinking skills if the technology is utilized appropriately. Also, its impact on students' self-concept, attitude toward school, attitude toward computers, and things students could do with computers deserve mentioning.

This study was conducted to investigate the effectiveness of CAI on students' higher-order thinking skills and its impact on students' attitude variables mentioned above. This was carried out by determining if there was a statistically significant difference among groups of students differentiated by reception of CAI with varieties of interactive software programs and grade level.

To test the hypotheses, six series of analysis of variance (ANOVA) were done. Analysis of variance results showed almost identical mean scores for both CAI and Non-CAI groups in inferences and grade level equivalent in reading and math. In other words, there was no significant difference between the two groups in those areas. In the same token, the analysis fielded the results that the mean scores difference approached statistical significance, with the CAI group having higher scores in generalizations and math problem solving.

In assessing the impact of CAI on overall academic achievement, the ANOVA results showed that the CAI group had a higher mean. The mean difference approached, but did not reach, significance, with the CAI group in grades one and two having higher mean scores. There was a significant grade level effect, $\underline{F}$ $(1,113) = 59.10$, $\underline{p} < .05$.

Other analysis of results showed that there were higher mean scores favoring the CAI group in self-concept, attitude toward school, attitude toward computers, and things they could do with computers. Comparing the means of CAI and Non-CAI groups in different grades, the CAI groups in grades one and two had higher means than did their counterparts in Non-CAI groups in self-concept, attitude toward school, attitude toward computers, and things they could do with computers. The results also showed that the CAI group in grade one had a higher mean score in those affective domains than did second grade students in CAI and Non-CAI groups respectively. There was a significant grade level effect in self-concept, F (1,130) = 33.53, $p < .05$. There was a significant difference between CAI and Non-CAI groups in attitude toward school, F (1,130) - 294.96, $p < .05$. The analysis showed that there was a significant difference between the experimental and control groups in their attitude toward computers and things they could do with computers, F (1,130) = 10.48, $p < .05$ and F (1,130) = 5.05, $p < .05$.

In assessing the impact of CAI on influences, generalizations, and math problem solving, a series of two-way analysis of variance were performed. The results showed that while the CAI group in grade one had a higher mean score in inferences than did their counterpart in the control group, the Non-CAI group in second grade had a higher mean score in inferences than did their counterpart in the experimental group.

The CAI group in grade one had a higher mean score in generalizations than did Non-CAI in the same grade. The CAI group in grade one had a higher mean score in generalizations than did students in second grade who were in either the CAI or Non-CAI group. There was a significant grade level effect favoring first grade in generalizations, F (1,129) = 84.14, $p < .05$.

In evaluating the impact of CAI on math problem solving, the results showed that the experimental group had a higher mean than did the control group. The first-grade students in the CAI group had a higher mean in math problem solving than their counterparts in the Non-CAI group. The contrary was the case with second grade. There was a significant interaction in math problem solving, F (1,121) = 4.87, $p < .05$. Subsequent analysis showed that first-grade students in CAI performed significantly better than their counterparts in the Non-CAI group in math problem solving. Also, the results further showed that first-grade students performed better in math problem solving than did second-grade students.

Discussion

The present study investigated the effectiveness of using CAI with varieties of interactive computer software programs to teach first- and second-grade students higher-order thinking skills, its effect on grade level, and impact it has on students' self-concept, attitude toward school, attitude toward computers, and things or skills they could learn or do with computers. Computers were used as tools to teach first- and second-grade students inferences, generalizations, and math problem solving in a computer lab setting. Based on the statistical findings of this study, discussions and conclusion are presented.

Burn and Hagerman (1989), in studying third-grade students using Logo computer programming, found that CAI positively affected children's problem solving and generalized thinking skills. This study confirms that finding with a sample from different populations and with a different ability measure. Also, the findings of this study are consistent with previous research that found that CAI significantly affected children's problem solving skills (Krendell & Lieberman, 1988; Riding & Powell, 1986) and that interacting with computers by children was not only beneficial to them but was also developmentally appropriate if used appropriately (Clements, 1987; Shade & Watson, 1990). The findings of the present study confirms that students who received CAI with varieties of interactive computer programs performed significantly better in math problem solving than did those students without the treatment. It was further found that first-grade students who were in the experimental group did perform significantly better in math problem solving than did first-graders in the experimental group.

The effect size in math problem solving favoring second graders in the CAI group was very small. One of the interesting findings was that first-grade students who received CAI scored higher in both math problem solving and generalizations than did second-graders who received CAI. Generally, first-graders had more ability to make generalization than did second-graders according to the findings of this study. Based on these findings, it is suggested that computers are developmentally appropriate for first-grade students.

It has been found by this study that age was a factor in demonstrating the ability to make inferences. Computer-assisted was effective in enhancing this ability at first-grade level, but not at second grade.

The impact of CAI on students' overall academic achievement was minimal and nonsignificant statistically. However, the effect size was more at first-grade level than at second-grade level. This same impact was true with grade level equivalent in reading and math.

The findings of this study appear to support earlier research in CAI and attitudes. Griffin, Gillis, and Brown (1986) and Krendell and Lieberman (1988) found that using computers significantly enhanced attitudes, especially attitudes toward computers. Dalton, Hannafin, and Hooper (1989) found the contrary to be true. In studying 60 eighth-grade students using computers, they found that there was no effect on their attitude toward instruction. In this study, the students who utilized CAI with varieties of interactive software programs had significantly higher attitudes toward school, attitudes toward computers, and things they could do with computers. There was a small, not statistically significant difference in self-concept favoring the CAI group. Self-concept theorists such as Combs and Snygg (1959), Rogers (1984), and Roebuck (1989) state that self-concept changes very slowly. It may be that if the treatment had been continued for longer than 4 months, the small difference might have attained significance.

Conclusions

In summary, it is obvious that due to the statistical findings for this study certain conclusions are warranted. It is concluded that computer-assisted instruction (CAI) with varieties of interactive software programs is an effective tool to teach higher-order thinking skills. It is especially more effective when students are exposed to computer environment in first grade. This indicates that the earlier exposed to computer technology appropriately, the more effective the tool will be in teaching higher-order thinking skills.

It is also concluded that while the abilities to make inferences are age-related favoring older children, the abilities to make generalizations and to do math problem solving are not. However, CAI with developmentally appropriate software programs could enhance children's abilities to make inferences.

Furthermore, CAI with varieties of interactive software programs tend to be more effective in enhancing affective domains than cognitive domains, especially in the first grade. Affective domains--attitude toward school, attitude toward computers, and things students could do witn computers--were more clearly positively affected by CAI than the cognitive domains.

Recommendations

Based on the findings of the present study, the following recommendations on new research, practice, and procedures were made for further study:

1. A replication of this study with a more representative population with regard to ethnicity.

2. A replication of this study with a better control group, a control group that will not interact with computers during the study.

3. A replication of this study with a more reliable and valid instrument to measure higher-order thinking skills.

Recommendations for Educational Practices

1. A replication of this study with computers that are equipped with voice, touchscreen, and joystick features.

2. A replication of this study with the opportunity for students to spend more time per week with computers for a longer period of time.

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APPENDICES

APPENDIX A

Letters of Approval

DISD

September 23, 1991

Mr. Iheanacho I. Orabuchi
2007 Teasley Lane #126
Denton, Texas 76205

Dear Mr. Orabuchi:

Your request to conduct a research study of one elementary school has been studied by the Research Review Committee and given their approval. You will at all times follow the policies of the Dallas Independent School District and work closely with Mr. James Reed as principal of the involved school.

Thank you for your interest in our schools. Best wishes for success in this particular venture. My office should receive a copy of your final dissertation.

Sincerely,

William J. Webster

William J. Webster
Division Executive
Evaluation and Planning Services

WJW:oe

cc: James Reed
Ed Baca

Dallas Independent
School District

Marvin Edwards
General Superintendent

3700 Ross Avenue
Dallas, Texas 75204-5491
(214) 824-1620

Indiana State University
Educational Foundations and Media Technology

September 30, 1991

Ms. Iheanacho Orabuchi
2007 Teasley #126
Denton, TX 76205

Dear Ms. Orabuchi

Enclosed are some of the instruments that you requested in your letter of September 9. I received it just today.

The instruments which are enclosed were developed for use in the evaluation of an instructional technology project for the Metropolitan School District of Mount Vernon, Indiana. They were used for a project during the 1987-88 school year and for another larger project in the 1990-91 school year.

The objectives for instruction constituted the basis for the test items that were developed. Consequently, the instrument has curricular validity.

Reliability estimates were also computed. The coefficients as well as an abstract of the study and results obtained from the instrument are enclosed.

This letter will constitute permission to use the instruments in your graduate work. Your dissertation should acknowledge the source of the instruments and give recognition to the M. S. D. of Mount Vernon, Indiana.

My best wishes for success in your research endeavors.

Sincerely,

David A. Gilman, Ph. D.
Professor of Education and
Editor, *Contemporary Education*

Terre Haute, Indiana 47809
(812) 237 2930

APPENDIX B

Software (SUNBURST)

SUNBURST

January 15, 1992

Iheanacho Orabuchi
2007 Teasley Lane #126
Denton, TX 76205

Dear Mr. Orabuchi,

Thank you for your letter of January 6, 1992.

Under separate cover, we are sending you the following software on 90 day approval:

1	Animal Rescue	Apple 3.5"
1	Trading Post	Apple 5.25" (it is not available in 3.5")
1	Muppet Math	Apple 3.5"
1	Mickey's Magic Reader	Apple 3.5"
1	Very First <in common> diskette	IBM 5.25" (it is not available in Apple)
1	What's in a Frame?	Apple 3.5"
1	Memory Building Blocks	Apple 3.5"
1	Odd One Out	Apple 3.5"

The following programs are on back order:

Mountain Monkey Math
The Nature Park Adventure
The Teddy Bears' Picnic
Cave Quest

Finally, playing with science is unavailable in Apple 3.5"

Please feel free to contact us if you need further assistance and thank you for thinking of Sunburst.

Sincerely,

Eleanor Arita

Eleanor Arita

EA/ls

WARREN SCHLOAT PRESIDENT

APPENDIX C

Software (VENTURA)

INVOICE 4271

CUSTOMER NO ORABUCHI

VENTURA EDUCATIONAL SYSTEMS
3440 BROCKENHILL STREET
NEWBURY PARK, CA 91320
(805) 499-1407

BILL TO

Iheanacho I. Orabuchi

2007 Teasley Lane #126
Denton, TX 76205

SHIP TO

Iheanacho I. Orabuchi

2007 Teasley Lane #126
Denton, TX 76205

DATE	SHIP VIA	FOB	TERMS
11/27/91	UPS	Origin	Net 150

PURCHASE ORDER NUMBER	ORDER DATE	SALESPERSON	OUR ORDER NUMBER
Orabuchi	09/27/91		

QUANTITY REQUIRED	QUANTITY SHIPPED	BO	ITEM NUMBER	DESCRIPTION	UNIT PRICE	AMOUNT
1	1		HA0029	Hands-On Math 1/5.25/Apple	59.95	59.95
1	1		HA0030	Hands-On Math 2/5.25/Apple	59.95	59.95
1	1		HA0031	Hands-On Math 3/5.25/Apple	59.95	59.95
				Invoice subtotal		179.85
				Discount		-179.85

From our Lending Library - Please Return

Thank You

APPENDIX D

Software (MECC)

MECC
3490 LEXINGTON AVENUE NORTH
ST. PAUL, MN 55126

1. PATTERNS (K-1)

APPENDIX E

Software (Tom Snyder Productions)

TOM SNYDER PRODUCTIONS
EDUCATIONAL SOFTWARE
90 SHERMAN STREET
CAMBRIDGE, MA 02140

1. READING MAGIC LIBRARY (AGES 2-6)
   (FLODD, THE BAD GUY)

2. CHOICES, CHOICES
   (TAKING RESPONSIBILITY)

APPENDIX F

Student Attitude Measure

M. S. D. Mt. Vernon, Indiana
Grade: ____________

Name: ____________
Teacher ____________

ABOUT

ME

AND

OUR SCHOOL

GRADE LEVEL
K/1
FORM A

Directions: Please listen as your teacher reads each of the sentences below. Place a cross (X) on the face that agrees with how you feel.

ABOUT ME

	YES	DON'T KNOW	NO
1. I like the way I am.			
2. I like the way I look.			
3. People at school like me.			
4. I am very smart.			
5. I learn new things quickly.			
6. My clothes look nice.			
7. I live in a nice house.			
8. I can do very well in school.			
9. I feel good about myself.			
10. I can do things right.			

ABOUT FRIENDS

	YES	DON'T KNOW	NO
11. I have a lot of friends.			
12. I'm always nice to other people.			
13. I try to be nice to everybody.			
14. I like to share with others.			
15. I like to help people.			
16. I like other people.			
17. I know how to make other people feel good.			
18. I need to have friends.			
19. I like being around other people.			
20. I say nice things to people.			

ABOUT MY SCHOOL

	YES	DON'T KNOW	NO
21. All my friends like our school.			
22. School is exciting.			
23. School is my favorite place.			
24. My teachers always help me.			
25. School is my favorite place.			
26. Everyone likes school.			
27. School is a good place.			
28. I love to go to school.			
29. I like my school and my teacher.			
30. I am learning a lot at school.			

ABOUT COMPUTERS

	YES	DON'T KNOW	NO
31. I love to work with computers.			
32. Computers help me a lot.			
33. Everybody should study with a computer.			
34. Everyone likes computers.			
35. Computers help you more than anything else.			
36. My life is better because of computers.			
37. Computers are wonderful.			
38. I learn better with computers.			
39. I enjoy computers a lot.			
40. I love computers.			

	I can use computers to	YES	DON'T KNOW	NO
41.	write a story or report.			
42.	play games.			
43.	practice Math.			
44.	learn about Science.			
45.	do a Science experiment.			
46.	learn to type.			
47.	send messages.			

48. take notes.

49. use a calculator.

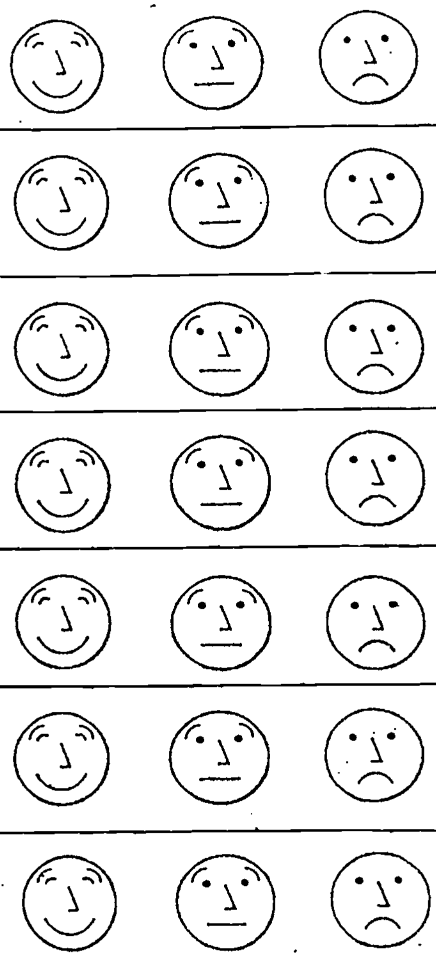
50. check spelling.

51. do word processing.

52. plan my writing.

53. organize.

54. learn to read better.



M. S. D. Mt. Vernon, Indiana
Grade: ____________

Name: ____________
Teacher ____________

ABOUT ME AND OUR SCHOOL

GRADE LEVEL
2/3
FORM B

Directions: Please listen as your teacher reads each of the sentences below. Place a cross (X) on the word that agrees with how you feel.

ABOUT ME

1. I like the way I am.	YES	DON'T KNOW	NO
2. People at school like me.	YES	DON'T KNOW	NO
3. I learn new things quickly.	YES	DON'T KNOW	NO
4. I live in a nice house.	YES	DON'T KNOW	NO
5. I feel good about myself.	YES	DON'T KNOW	NO
6. I don't like the way I look.	YES	DON'T KNOW	NO
7. I'm not very smart.	YES	DON'T KNOW	NO
8. My clothes don't look nice.	YES	DON'T KNOW	NO
9. I'm not good enough to do well in school.	YES	DON'T KNOW	NO
10. I can't do anything right.	YES	DON'T KNOW	NO

ABOUT FRIENDS

11. I have a lot of friends.	YES	DON'T KNOW	NO
12. I try to be nice to everyone.	YES	DON'T KNOW	NO
13. I like to help people.	YES	DON'T KNOW	NO
14. I know how to make people feel good.	YES	DON'T KNOW	NO
15. I like being around people.	YES	DON'T KNOW	NO
16. I'm never nice to other people.	YES	DON'T KNOW	NO
17. I don't like to share with others.	YES	DON'T KNOW	NO
18. I don't like other people.	YES	DON'T KNOW	NO
19. I don't need any friends.	YES	DON'T KNOW	NO
20. I never say nice things	YES	DON'T KNOW	NO

ABOUT MY SCHOOL

21. All my friends like our school.	YES	DON'T KNOW	NO
22. My teachers always help me.	YES	DON'T KNOW	NO
23. School is my favorite place.	YES	DON'T KNOW	NO
24. School is a good place.	YES	DON'T KNOW	NO
25. I like school and my teacher.	YES	DON'T KNOW	NO
26. School is boring.	YES	DON'T KNOW	NO
27. I wouldn't feel bad if we didn't have school.	YES	DON'T KNOW	NO
28. Nobody likes school.	YES	DON'T KNOW	NO
29. I hate to go to school.	YES	DON'T KNOW	NO
30. I'm not learning anything at school.	YES	DON'T KNOW	NO

ABOUT COMPUTERS

31. I love to work with computers.	YES	DON'T KNOW	NO
32. Everybody should study with computers.	YES	DON'T KNOW	NO
33. Computers help you more than anything else.	YES	DON'T KNOW	NO
34. Computers are wonderful.	YES	DON'T KNOW	NO
35. I enjoy computers a lot.	YES	DON'T KNOW	NO
36. Computers don't help me at all.	YES	DON'T KNOW	NO
37. Nobody likes computers.	YES	DON'T KNOW	NO
38. My life would be better without computers.	YES	DON'T KNOW	NO
39. I could learn better without computers.	YES	DON'T KNOW	NO
40. I hate computers.	YES	DON'T KNOW	NO

I can use computers to

41. write a story or report.	YES	DON'T KNOW	NO
42. play games.	YES	DON'T KNOW	NO
43. practice Math.	YES	DON'T KNOW	NO
44. learn to read better.	YES	DON'T KNOW	NO
45. learn about Science.	YES	DON'T KNOW	NO
46. do a Science experiment.	YES	DON'T KNOW	NO
47. learn to type.	YES	DON'T KNOW	NO
48. send messages.	YES	DON'T KNOW	NO
49. take notes.	YES	DON'T KNOW	NO
50. use a calculator.	YES	DON'T KNOW	NO
51. check spelling.	YES	DON'T KNOW	NO
52. do word processing.	YES	DON'T KNOW	NO

53. plan my writing.	YES	DON'T KNOW	NO
54. organize.	YES	DON'T KNOW	NO