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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AUGUST 1992

TEXAS WOMAN'S UNIVERSITY
DENTON, TEXAS

<u>JUNE 30, 1992</u>
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.

_____
Dr. Sam Ed Brown, Major Professor

We have read this dissertation
and recommend its acceptance:

_____
_____
_____
_____
Department Chairperson

_____
Dean of College

Accepted
_____
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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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

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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).

Inferences--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 integrati 1" (p. 373).

CAI--according to <u>Computer Dictionary for Everyone</u>,
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). <u>Dictionary of Information Technology</u>
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).

<u>Self-Concept</u>--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

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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 consequential. 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 $= \dfrac{(A + B)}{(C + D + E)}$

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 ot 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

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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 llGS and llE 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

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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	$\underline{N}$
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

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. <u>ANOVA Table</u>

<u>Source of Variation</u>	<u>SS</u>	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>P</u>
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.

<u>Attitude toward Computers</u>. 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. <u>ANOVA Table</u>

<u>Source of Variations</u>	<u>SS</u>	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>P</u>
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.

<u>Things or Skills Students Could Do With Computers</u>. 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

B. <u>ANOVA Table</u>

<u>Source of Variations</u>	<u>SS</u>	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>P</u>
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.

<u>Decision</u>. 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. <u>ANOVA Table</u>

<u>Source of Variations</u>	<u>SS</u>	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>P</u>
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.

<u>Decision</u>: 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	$\underline{N}$
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. <u>ANOVA Table</u>

Source of Variations	<u>SS</u>	<u>DF</u>	<u>MS</u>	<u>F</u>	<u>P</u>
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   ANOVA   Rejected,

statistically significant $p < .05$

difference in generaliza-

tions 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.

6. There will be no   ANOVA   Rejected,

    statistically significant $p < .05$

    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..

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.

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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, F (1,113) = 59.10, 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
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

M&. Iheanacho Orabuchi
2007 Teasley #126
Denton, TH 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 N. Gilman, Ph. D.
Professor of Education and
Editor, *Contemporary Education*

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

EA/ls

APPENDIX C

Software (VENTURA)

INVOICE 4271

CUSTOMER NO. ORABUCHI

VENTURA EDUCATIONAL SYSTEMS
3440 BROKENHILL 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	F O B		TERMS	
11/27/91	UPS	Origin	Net 150		

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

QUANTITY			ITEM NUMBER	DESCRIPTION	UNIT PRICE	AMOUNT
REQUIRED	SHIPPED	BO				
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   Name:_____
Grade: _____   Teacher_____

ABOUT

ME

AND
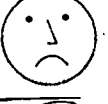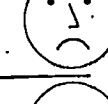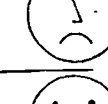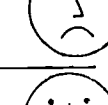
OUR   **SCHOOL**

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.
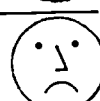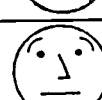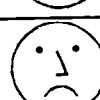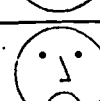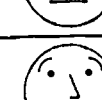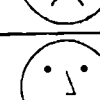
ABOUT ME

	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
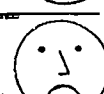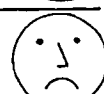
	YES	DON'T KNOW	NO
11. I have a lot of friends.	☺	😐	☹
12. I'm always nice to other people.	☺	😐	☹
13. I try to be nice to everybody.	☺	😐	☹
14. I like to share with others.	☺	😐	☹
15. I like to help people.	☺	😐	☹
16. I like other people.	☺	😐	☹
17. I know how to make other people feel good.	☺	😐	☹
18. I need 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   Name:_____
Grade: _____   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

130

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　　NO
　　　　　　　　　　　　　　　　　　　　　KNOW

54. organize.　　　　　　　　YES　　　DON'T　　NO
　　　　　　　　　　　　　　　　　　　　　KNOW