Order Number 9204447

Effects of computer technology and traditional methods of instruction upon the critical thinking skills of teachers and students

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The University of North Carolina at Greensboro, 1991

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EFFECTS OF COMPUTER TECHNOLOGY AND TRADITIONAL METHODS OF INSTRUCTION UPON THE CRITICAL THINKING SKILLS OF TEACHERS AND STUDENTS

by

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

Greensboro
1991

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APPROVAL PAGE

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March 15, 1991
Date of Acceptance by Committee

March 15, 1991
Date of Final Oral Examination

KEZAR, Lois Paulson, Ed.D. Effects of Computer Technology and Traditional Methods of Instruction upon the Critical Thinking Skills of Teachers and Students. (1991) Directed by Dr. Kieth C. Wright. 94 pp.

The purpose of this study was to investigate the effectiveness of computer technology in developing critical thinking skills of teachers and middle school students. The influences of years of teaching experience and educational degrees held by the teacher upon teacher gains and student gains were also investigated. In addition, this study examined the relationship between achievement test scores and critical thinking scores.

The sample consisted of 20 classroom teachers and 449 fifth and sixth grade students at a middle school in rural Piedmont North Carolina. Ten teachers and 239 students were in classrooms with computers, while the control group of 10 teachers and 210 students did not have computers.

A $\underline{t}$ test for gain scores (posttest scores minus pretest scores) of the computer group with the control group indicated a significantly greater gain ($\underline{p} < .0001$) for computer students than non-computer students. Teacher gains were not significant.

A Pearson correlation revealed a significant ($\underline{p} < .005$) inverse relationship between years of teaching experience and student gain scores. Students of teachers with the fewest years of experience had the highest gain scores.

California Achievement Test (CAT) scores were compared with scores on the Cornell Critical Thinking Test (CCTT). The results of a regression analysis indicated that for all students in the sample ($n = 100$), the CAT reading score was the best predictor of overall CCTT gain scores ($p < .03$). CAT scores were less predictive at the sixth grade level than at the fifth.

Mean overall gain scores for the 20 individual classrooms ranged from -1.04 to 6.4 with a mean gain of 2.4. An overview of classrooms based on teachers' logs and interview questions indicated that teachers in the classrooms with the highest gain scores treated critical thinking as a separate subject, used a direct approach in teaching critical thinking skills, frequently used a cooperative learning approach, and used the computer for reinforcement but did not depend upon it to teach.

ACKNOWLEDGMENTS

I sincerely thank my adviser, Dr. Kieth C. Wright, and the members of my committee--Dr. Elisabeth Bowles, Dr. D. Michelle Irwin, Dr. Samuel D. Miller, and Dr. Rebecca M. Smith--for their guidance on this project.

I am also grateful to my husband, Ed, and to my daughters, Kirsten and Sara, for their support and to my father-in-law, Howard Kezar, now deceased, for encouraging me to begin this project.

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CHAPTER I

INTRODUCTION

Statement of the Problem

America is moving from an Industrial Era to an Information Age. In 1950 only 17% of the North American work force worked in information jobs. The majority of workers were involved in production. Of the 19 million new jobs created during the 1970s, however, only 5% were in manufacturing. Today, more than 60% of America's work force is involved with information processing. It is estimated that the information half-life (the time period during which half the information in a field becomes outdated) of some fields is only 6 years. Stated another way, scientific and technical data which have been doubling every 5 years are expected to double every 20 months during the decade of the 1990s (Moynes, 1984).

The rapid increase of knowledge has implications for classroom teachers who frequently point to the impossibility of covering all the material in the content areas. Ever-expanding fields of knowledge require teachers to take a different approach. Rather than requiring students to memorize more and more information, teachers must help them to develop life-long learning and thinking skills (McTighe & Schollenberger, 1985).

Naisbitt (1982) emphasizes not only the significance of the information revolution but the influence of globalism. The world is rapidly becoming a single marketplace. Today's students are citizens of a world in which they will be expected to deal with issues beyond our borders.

> Critical thinking can help students make the important journey to the other person's perspective. . . . We owe it to ourselves and future generations to occupy this world rationally, and to not accept what we hear and see on faith alone. Critical thinkers use critical thinking skills and possess an attitude that enables them to maintain an objective, constructive, and questioning stance toward all the information they receive. Finally, critical thinkers participate--they vote, examine issues, communicate wthout jargon, offer opinions, and value the viewpoint of others. (Kneedler, 1985, p. 280)

Purpose and Objectives

The purpose of this study was to determine the effectiveness of computer technology in developing the thinking skills of teachers and their students. One objective was to investigate the relationship of a staff development workshop to teacher gains in critical thinking scores. Another objective was to compare gains in teacher thinking with gains in student thinking. A third objective was to investigate the influence of teaching experience and degrees held upon the critical thinking scores of teachers and students. A final objective was to analyze the relationship between achievement test scores and critical thinking scores.

Statement of Hypotheses

The following directional hypotheses were developed:

1. Gain scores of teachers and students using computer technology will be significantly higher than gain scores of those using only traditional methods.

2. There will be a positive relationship between teacher gains in critical thinking and gains of their students measured by the Cornell Critical Thinking Test.

3. Teachers' posttest scores on the Cornell Critical Thinking Test will be significantly different from pretest scores after a workshop utilizing computer technology and traditional methods of instruction.

4. Number of years of teaching experience will not significantly influence gains made by teachers and their students.

5. Educational degrees held by the teacher will not significantly influence teacher gain or student gain.

6. CAT scores will be significantly related to gains made by students.

Significance of the Study

The literature suggests that computer technology has great potential in the development of critical thinking. This study was an attempt to determine the effectiveness of computers in teaching critical thinking skills in fifth and sixth grade. The findings should be useful to administrators and teachers who plan to incorporate critical thinking into a middle school curriculum. The study provides data suggesting where the influence of the computer was the greatest and describing the teaching strategies which were associated with the greatest gains in students' critical thinking scores.

Definition of Terms

The following operational definitions are included to clarify the critical thinking terminology used in this study:

Thinking skills. Thinking skills are mental techniques or abilities that enable human beings to formulate thoughts, to reason about, or to judge (Beyer, 1984, p. 486).

Teaching strategy. A teaching strategy is a sequential arrangement of instructional activities employed over time and intended to achieve a desired student learning outcome (Costa, Hanson, Silver, & Strong, 1985, p. 141).

Critical thinking. Critical thinking is reflective and reasonable thinking that is focused on deciding what to believe or do (Ennis, Millman, & Tomko, 1985, p. 45). In this study critical thinking includes deduction, induction, credibility, and assumption identification.

Deduction. Conditional propositions in reasoning refer to arguments which contain the "if-then" premise in which the truth of Condition B depends on the truth of Condition A (If A then B.) (Black, 1952, pp. 54-57).

Induction. Induction in this study involves the use of best-explanation criteria. It includes drawing conclusions and supporting hypotheses (Ennis et al., 1985, pp. 28-29).

Credibility. Judgments about credibility are judgments about whether and to what extent to believe someone else's assertion, usually in a situation in which the judger has no direct access to the basis for the assertion (Ennis et al., 1985, p. 25).

Assumption identification. The basic criterion for an assumption is that it fills the gap in reasoning (Ennis et al., 1985, p. 26).

Scope and Limitations

Developmental theory suggests that during the middle school years, students are moving from the stage of concrete operations toward a period which allows the kind of abstract reasoning which is necessary for critical thinking. Therefore, this study will be limited to Grades 5 and 6. No attempts should be made to generalize findings to other grade levels.

Critical thinking as defined in this study includes deduction, induction, credibility, and assumption identification. No attempts should be made to generalize findings to other higher order skills which fall into the category of critical thinking.

The participation of teachers from only one school does not allow for the expectation that teachers in the population at large would show the same degree of change as those participating in this study. The pretest-posttest control group design does not control for the interaction of the pretest and therefore care should be taken in generalizing to a larger untested population.

All the teachers in this study participated in the critical thinking workshop. The absence of a control group does not permit generalizing the effects of the workshop.

Summary

The advent of the 21st century is placing unprecedented pressure on schools to teach students to think rather than to simply absorb the content of various subjects. Evidence is mounting that students' reasoning skills are not well developed. But despite the lip service paid to the need for instruction in this area, critical thinking curricula are often viewed as only appropriate for high ability students or too demanding of the teachers' time and effort. Therefore, teachers continue to teach in much the same way that they were taught, and students remain unprepared for the demands which the next century will put upon their thinking (Quellmalz, 1984). The literature suggests that computer technology has great potential in resolving this educational dilemma.

This study attempted to determine the effectiveness of computers in teaching critical thinking skills in fifth and sixth grade. The following questions were addressed:

1. Will teachers and students using computer technology make greater gains in critical thinking than those using traditional methods?
2. Will students and teachers show similar gains in critical thinking?
3. Will years of teaching experience and educational degrees held by the teacher be related to gains made by teachers and their students?
4. Will students' achievement test scores be related to their critical thinking scores?

CHAPTER II

REVIEW OF LITERATURE

Theoretical Background

Developmental theory incorporates the concept of stage development from several perspectives. Developmentalists and others in this century have made notable contributions to current theories about thinking.

John Dewey

Reflective thinking was described by Dewey (1933) as a conscious and voluntary effort to reach a conclusion by using evidence and rationality. Dewey envisioned a democratic society in which citizens made decisions based on deliberation, discussion, and the exercise of reasoning and knowledge. Genuine freedom was defined as "trained power of thought" (p. 90). Largely due to Dewey's influence, a primary goal of American education during the 1920s and 1930s was the development of reasoning ability (Cuban, 1984).

Jean Piaget

Piaget has described four stages in the development of logical reasoning. Each stage, or period, builds upon the previous one allowing the individual to deal with more complex variables. Appropriate educational experiences can facilitate this cognitive growth. During the sensorimotor period (birth to 2 years) the infant differentiates himself from objects. The second period is divided into two phases. In the preoperational phase (2 to 4 years) the child is unable to take the viewpoint of other people. He is able to classify using a single salient feature. During the intuitive phase the child (4 to 7 years) is able to think in terms of classes, to see relationships, and to use number concepts. The period of concrete operations (7 to 11 years) is one in which the child uses logical operations such as reversibility, classifies into hierarchies of classes, and organizes objects into ordered series such as increasing size. During the period of formal operations (11-15 years) a child takes the final step toward abstract thinking and conceptualization. He is capable of testing hypotheses (Wilgard & Atkinson, 1967).

J. P. Guilford

Like Piaget, Guilford (1967) views intelligence as the child's capacity to build on his experience. To Piaget, however, intelligence seems to be a gradual process culminating in the stage of formal operations. Guilford is not concerned with progression or development in intelligence. He sees each child as a unique combination of 120 specific intellectual abilities. Guilford suggests that education should have three objectives: (a) to promote the possession of information (cognition), (b) to emphasize the use of information (production), and (c) encourage the evaluation of information (critical thinking).

Benjamin Bloom

Bloom (1956) has developed a classification scheme of the cognitive domain to help identify hierarchical levels of thinking. Bloom's six hierarchical levels of cognition are:

1. Knowledge. Facts provide the foundation for higher levels of thinking, but classroom questions should not be limited to those which are factual.

2. Comprehension or understanding. Students must have and understand background information before they can move on to higher levels of thinking. "Why" and "how" questions can be used to test understanding at this level. Students should be able to explain in their own words rather than simply repeating what they have read or heard.

3. Application. This is the beginning of creative thinking. It involves the ability to apply learning to new situations.

4. Analysis. The fourth level of cognition involves the ability to perceive similarities and differences and to categorize in order to organize information.

5. Synthesis. This requires the student to create or invent poems, pictures, organizational schemata, generalizations, or hypotheses.

6. Evaluation. Evaluation is concerned with the ability to make value judgments. Specific ideas, objects, or activities may be valued differently by different individuals. Quick decisions not preceded by careful consideration of the idea, object, or activity being judged are opinions, not judgments. To require students to give reasons for their judgment based on criteria is asking them to operate at the highest level of cognition. Learning outcomes at this level contain elements of all the other levels. There are no right or wrong answers; a conclusion is considered to be valid when evidence supports it (Bloom, 1956).

Robert Gagne

Gagne (1985) suggests that any intellectual skill can be analyzed and divided into a series of simpler skills. The process of charting or analyzing the relationship of subordinate skills to complex skills is called a learning hierarchy. In order to learn complex skills, the simpler skills must be retrieved to working memory. Then cues to their combination or proper sequence must be provided, usually by means of statements which teachers make. The internal process of learning must be supported by external events, or instruction (Gagne & Driscoll, 1988).

Summary

Dewey's concern that reflective thinking be an integral part of the public school curriculum seems as relevant at the end of the 20th century as it was at the beginning. Piaget's stages of cognitive growth have established a means of determining when more complex thinking skills can appropriately be introduced. Guilford departed from the concept of stages. He saw each child as a unique combination of 120 specific intellectual abilities. Bloom has identified six hierarchical levels of cognition culminating in evaluation which requires students to make criteria-based judgments. Gagne has suggested that more easily learned lower levels of knowledge are prerequisites to understanding more complex ideas. Each theory views cognition from a different perspective, but all are concerned with promoting the highest possible levels of thinking and behaving.

Research

Significant research in three areas has been reviewed for this study. These include relevant research on critical thinking, computer technology, and staff development.

Critical Thinking

Goodlad's (1983) Study of Schooling found that, on the average, only 5.2% of classroom time was spent on discussion. Teachers "out-talked" all students in their classes by a ratio of three to one. Feedback-with-guidance which is associated with helping students gain understanding was virtually non-existent. The Excellence Report (National

Commission on Excellence in Education, 1983) expressed concern that 17-year-olds did not demonstrate the expected higher order thinking skills. Nearly 40% could not draw inferences from written material. Only 20% could write a persuasive essay. Less than 34% could solve a mathematics problem requiring several steps.

Representatives of various subject areas including mathematics (Behout & Carpenter, 1989), English (Tchudi, 1988), social studies (Kurfman & Cassidy, 1977), and art (Duke, 1984) have cited the necessity for teaching students to think. For more than a decade Vermont has mandated the teaching of thinking in certain subject areas. California, New Jersey, Connecticut, and Michigan have developed plans to assess thinking (Beyer, 1987). In 1984 the Massachusetts State Department of Education targeted the teaching of thinking as one of its major goals (Murray, 1985). North Carolina's Basic Education Program (1988) encourages the development of higher level thinking in every subject area. National testing agencies are giving more attention to complex thinking skills. Therefore, implementation of higher level thinking may become a survival skill for school systems and teachers as well as for students (Beyer, 1987).

Thinking skills and developmental levels. It is important for young learners to be introduced to basic thinking skills during the early years of schooling

(Presseisen, 1985). Bellanca (1985) suggests the following sequence for introducing thinking skills in the curriculum based on developmental stages. In the primary grades observing, sequencing, patterning, finding likenesses and differences, grouping, naming, predicting, and goal setting would be introductory skills. In the middle grades students would move from concrete examples to more abstract concept formation. In high school students would work toward mastery of problem solving and logical reasoning.

Arons (1985) concurs that reasoning and understanding should be matched to intellectual development at every age. His concern is that appropriate guidance and instruction in reasoning are not being provided. During the 1970s, investigators (Chiapetta, 1976; Epstein, 1978; McKinnon & Renner, 1971) began administering elementary Piagetian tasks in logical reasoning to adolescents and young adults. Overall averages indicate that approximately one-third of the individuals tested solved the tasks correctly; another one-third performed incorrectly but had a partial grasp of the necessary mode of reasoning; the remaining third failed completely. "In Piagetian terminology, the first group might be described as using formal patterns of reasoning, the third group as using principally concrete patterns, and the middle group as being in transition between the two modes" (Arons, 1985, p. 149). In working with inservice teachers and college students who were not using formal patterns of reasoning, Arons reported that the fraction who performed successfully rose from 10% to 70-90% depending on the nature of the tasks. Remediation started with basic, concrete operations and experiences. Students were allowed to make and rectify mistakes. They were required to explain their reasoning. The same modes of reasoning were repeated in different contexts and at different times. However, approximately 15% of the students never developed the capacity to perform the given tasks successfully, even with additional tutoring and repetition.

Stone and Day (1978) randomly assigned 28 children between the ages of 9 and 13 to a control group and a treatment group. Both groups were asked to perform a Piagetian task, but the treatment group was given the appropriate rule to follow. A significant difference in reasoning skills was displayed by the treatment group. It was concluded that latent cognitive abilities can be developed with instructional intervention. "One important component of cognitive development and of cognitive performance in general lies in the metacognitive awareness of when and where to use the skills in one's possession" (p. 1065).

Case (1978) describes the discrepancy between Piaget's theory and empirical research as a difference between ability and performance. Children at a given age may have the necessary ability but lack the tools to successfully complete a task. Case refers to these tools as "executive strategies" or control structures because they incorporate lower-level cognitive skills. He says that students must receive direct instruction in strategies for organizing their cognitive skills through practice, feedback, cue highlighting, and modeling. Through instruction the age is reduced at which a given executive strategy can be acquired.

Wirtz (1985) agrees that appropriate tools must be provided and suggests that there are two operational directions to move at each developmental level:

1. Toward increasing levels of abstraction
   a. concrete objects
   b. representations
   c. abstractions
2. Toward higher cognitive levels
   a. remembering experiences
   b. solving problems
   c. making investigations (pp. 100-101).

Bellanca (1985) recommends that no more than six thinking skills be introduced at each grade level. Beyer (1987) would set a limit of two to four. Previously learned skills should be reviewed and expanded. Teachers must (a) isolate the desired level of thinking, (b) model the thinking skill, (c) structure the thinking experience so all students are involved, and (d) encourage transfer of the skill to other academic areas (Bellanca, 1985).

Cognition and metacognition. Thinking is "the mental process by which individuals make sense out of experience" (Beyer, 1987, p. 16). It involves two operations: cognition and metacognition. Cognitive operations are used to generate or find meaning. Metacognition is thinking about thinking. The major metacognitive operations include planning, monitoring, and assessing one's thinking. "Any act of thinking combines operations designed to produce meaning (cognitive operations) with those that direct how that meaning is produced (metacognitive operations)" (Beyer, 1987, p. 17).

Certain thinking processes may be more applicable to some content areas than to others. For example, problem solving fits well into the science and mathematics curriculum. Decision making can be applied in social studies and vocational studies. Critical thinking can be developed in language arts and government classes. Creative thinking can be enhanced in art, music, and literature classes (Presseisen, 1985).

An area that has received little attention by researchers concerns the relative impact of various concept teaching models on the overall thinking and reasoning abilities of students. Cognitive activities may be triggered during the teaching process either inductively or deductively. Ceballos (1986/1987) randomly assigned fourth grade students to two treatment groups. The first treatment consisted of an inductive approach for teaching concepts; the second utilized a deductive approach. It was concluded that inductive and deductive approaches were equally effective in promoting concept formation and in fostering metacognitive strategies.

Process or strategy training. Research supports the position that learning appropriate strategies, or the process, can be as important as learning the content. Worsham and Austin (1983) reported significantly higher verbal scores on the Scholastic Aptitude Test (SAT) for students who received instruction in thinking skills for two periods each week (two-fifths of their total English program) than for those who received regular instruction in English. Link (1983) reported that school systems using Feuerstein's (1980) Instrumental Enrichment Program showed significant differences on the California Achievement Test (CAT) between the thinking skills group and the control group that received only content instruction. In another study (Braxton, 1973) conditional logic was taught to students in Grades 7-9 for 30 minutes each day for 10 days. At the conclusion of the study the group which received instruction in thinking skills scored significantly higher on the Cornell Conditional Reasoning Test than did the control group.

Haws (1983/1984) tested three separate methodologies for promoting reasoning skills in students: (a) a logical reasoning methodology, (b) a dialogue methodology, and (c) a combined logical reasoning and dialogue methodology. Sixth graders from a private school were randomly assigned to the three experimental groups and a control group. The combined logic/dialogue group scored statistically higher than the other groups on the Questioning Task 4 of the Philosophy for Children Instrument and the Moral Judgment Interview.

Teagle (1986) used the Junior Great Book Series to instruct students in Grades 5 and 6 in Socratic skills which included induction, deduction, and assumption. Although significant differences were not found between the experimental and control groups on overall scores on the Cornell Critical Thinking Test, there were significant differences on the subscales. On the induction subscale, the experimental boys scored higher than the control boys and girls in both groups. The experimental group outperformed the control group on the deduction subscale. The girls scored higher than the boys on the assumption subscale.

Direct instruction. Some would argue that more important than teaching children to think is giving them opportunities to think and to discuss what they are doing. However, research suggests that teachers overestimate the ability of students to learn indirectly (Ashby-Davis, 1984). Mere explanations followed by the opportunity to try a new strategy do not guarantee success. Generally, studies which have focused on the direct instruction of thinking skills have shown higher posttest scores on instruments which measure reasoning ability (Ashby-Davis, 1984; Braxton, 1973; deBono, 1983; Link, 1983). However, there are contradictory reports. Baldwin (1987) randomly assigned seventh grade students to classes that received conventional social studies content as well as direct instruction in analytical thinking skills and to classes that received only conventional studies content. IQ appeared to be a greater predictor of growth of reasoning ability than either direct or indirect instruction of reasoning skills. Students with higher IQ scores appeared to make greater gains in posttest reasoning scores than did students with lower IQ scores. Hopkins (1986/1987) examined the relationship between eighth grade students' achievement on a thinking skills instrument and CAT scores. On the Test of Cognitive Skills the experimental group which received direct instruction in thinking skills showed significant gain but was outscored by the control group on total scores and on each subtest except the one involving analogies. Students' achievement of the posttest assessment was predictive of their achievement of the CAT.

Salomon's (1974) studies indicated that students with lower aptitude scores profited more from modeling of specific strategies than did students who had high aptitude scores. It was suggested that the modeling of new behaviors might have interfered with the already developed strategies of brighter students and hindered their performance. Sternberg (1981) argues that students need not only a reservoir of strategies to call upon but the ability to determine the best choice in a given situation.

Beyer (1987) suggests that it may be difficult for students to think while processing information they are trying to learn. Lessons that focus on subject matter may obscure the nature of the thinking processes involved. Therefore, in the early stages of developing a new thinking skill, it seems better to concentrate on thinking as the subject matter to be learned. The direct teaching of thinking provides students with models of performance and requires them to tell how, why, and when particular operations were executed. In this way, not only proficiency but understanding is developed. Eventually, a new skill can be applied to other areas. Continued instruction of a skill in various subject areas not only reinforces the skill but also produces better learning of the subject matater. Subject matter, therefore, gives purpose to thinking.

<u>Summary</u>. Thinking involves two operations: cognition and metacognition. Cognition refers to the process of finding meaning. Metacognition is thinking about thinking or

evaluating one's thoughts. Both operations are necessary for critical thinking to occur. Piagetian theory suggests that at about the age of 11 or 12 (the middle school years), students begin moving from the concrete operational stage to the formal operational stage. This means that they are able to begin thinking abstractly and to conceptualize. However, research indicates that unless these students have had sufficient experience with prerequisite skills in the primary grades, there will be a discrepancy between the age appropriate abilities described by developmental theory and student performance. Teachers must provide the necessary tools and opportunities for practice.

Computer Technology

Computers provide unique possibilities for the promotion of learning, although experts agree that for the most part these possibilities are still unrealized. It is estimated that fewer than 15% of all teachers in the United States actually use computers in their classrooms (McCarthy, 1988) and that approximately 60% of educational software is of the drill and practice variety (Rubin & Bruce, 1984).

Early experiments in computer-aided instruction (CAI) included only drill and practice. Results were measured by achievement test scores. Visonhaler and Bass (1972) reviewed ten major studies involving elementary students and concluded that for both mathematics and language arts CAI was an effective tool.

The Educational Testing Service (ETS) conducted a 5-year study of CAI in compensatory education for the Los Angeles Unified school District (Ragosta, 1981). The CAI consisted of drill and practice programs. Students with up to 20 minutes of CAI daily in math scored significantly higher on the Iowa Test of Basic Skills (ITBS) than did students who received the same amount of traditional instruction. CAI students showed gains over those who received traditional instruction in language arts and reading, but the differences were not significant.

Findings from 51 studies which included both computer-assisted instruction and computer-managed instruction were compiled by Kulik, Bangert, and Williams (1983). The results were consistent with earlier reports. Students who received computer-based instruction increased their achievement scores by .32 standard deviations, or from the 50th to the 63rd percentile. Other studies indicate that CAI requires less time than traditional methods to learn the same materials (Bracey, 1982; Edwards, Norton, Taylor, Weiss, & Dusseldorp, 1975; Rapaport & Savard, 1980).

More recently, computers have been used to the development of critical thinking. Seymour Papert (1980), the creator of LOGO, was one of the first to challenge the idea that computers could only be used for drill and practice. The use of programming languages to promote intellectual development has received considerable attention (Feurzeig, Papert, Bloom, Grant, & Solomon, 1969; Hanna, 1986; Littlefield, Delcios, Bransford, Clayton, & Franks, 1989; Sattler, 1987; Upchurch & Lochhead, 1987).

Programs promising to develop critical thinking within various subject areas are beginning to fill the pages of software catalogs, but the effectiveness of most programs remains to be measured. The skills they are designed to promote and the approaches that are used vary widely.

The Higher Order Thinking Skills (HOTS) program developed by Pogrow (1985) has been evaluated. It has been implemented in Grades 3-6 in the belief that Grades K-2 should focus on conventional programs and that instruction in thinking skills should take place before Grade 7. HOTS is a pull-out compensatory program for Chapter 1 students. Work at the computer is preceded by a thinking discussion in which students articulate the possible consequences of their proposed strategies. First-year evaluations indicated that reading scores had improved and students performed better on higher-order thinking tasks than did students at the control schools.

Studies have been conducted to compare the effectiveness of CAI with traditional methods of teaching a general course on thinking skills. Lance (1986) compared the thinking strategies of 23 fifth grade students who were exposed to print stimuli with another 23 students who were exposed to computer stimuli. Findings indicated that the computer program stimulated a greater number of thinking strategies than did the printed materials.

Perkins (1984/1985) compared the thinking skills of seventh grade students. Five classes were assigned to two treatment groups and five were assigned to a control group. A 9-week course in critical thinking was alternately taught using traditional instruction (lecture, discussion, games, and worksheets) and computer software covering the same instructional objectives. The control group received no special instruction in critical thinking. Students in both treatment groups scored significantly higher than the control group in verbal analogies as measured by the Ross Test of Higher Cognitive processes. No significant differences were found among the control, microcomputer, and conventional groups on logical reasoning, inductive/deductive reasoning, or problem analysis skills. No differences in scholastic aptitude as measured by the Otis-Lennon Mental Ability Test were found.

Summary. Most of the research on CAI has involved drill and practice programs. Generally, the results indicate an increase in achievement test scores with CAI over traditional methods of instruction. Studies also suggest that students learn faster with CAI than with conventional methods. The increasing availability of software to teach thinking skills suggests that there may now exist a way of teaching these strategies which was not possible before the advent of computers (van Deusen & Donham, 1986/87).

Staff Development

Educators and employers agree that higher level thinking and computer competencies are survival skills for the Information Age which we have already entered. The deliberate teaching of thinking skills and familiarity with computers are new responsibilities being placed upon teachers. Merging the two can be a formidable staff development task (Matsumoto, 1985).

Joyce, Howey, and Yarger (1976) conducted a massive study of inservice teacher education. The results were generally negative. It was concluded that most programs were ineffective. Since then, efforts have been made to improve inservice education. Joyce and Showers (1980) reviewed 200 research studies on teacher training. They identified five major components of successful programs:

1. The presentation of <u>theory</u> related to practice raises awareness and contributes to professionalism.
2. <u>Modeling</u> involves a demonstration of the teaching skill with children or adults or through some form of media.

3. Practice can take place in a simulated or classroom setting.
4. Feedback has a positive impact on awareness of teaching behavior and provides knowledge about alternatives.
5. Coaching for application helps teachers analyze content to be taught and approaches to be used.

Newmann, Onosko, and Stevenson (1988) used a different approach but their findings were similar. Twenty-five staff developers who have worked intensively with teachers to promote higher order thinking were surveyed. Three activities were rated as "absolutely necessary" by 24 of them:

1. Teachers themselves must be involved in higher order thinking activities in their subject fields.
2. Time must be provided for teachers to translate ideas about teaching thinking into lesson plans.
3. Teachers must try out these activities in their classes.

The discouraging aspect of the survey was that while staff developers expressed enthusiasm about apparent growth in individual teachers, they were unable to identify a single school or a department in which staff development had led to long-term instructional changes. This was congruent with Marzano's (1987) research. What are needed are organizational changes and ongoing institutional support, but

> to postpone individual training until schools commit themselves to more fundamental reforms could be self defeating, because teachers educated in the promotion of thinking are needed as agents for both incremental and substantial advances in this area. (Newmann, Onosko, & Stevenson, 1988, p. 12)

Commercial programs. With the increasing awareness of the need to teach thinking skills, commercial programs have begun to emerge. Kruse and Presseisen (1987) cataloged 29 of these according to their purposes. Some programs were designed primarily for teachers; others were designed for students at the elementary, middle school, or secondary level. Costa (1985) described 15 programs for teaching thinking. Some of these overlap with the ones listed by Kruse and Presseisen. Volumes edited by Chipman, Segal, and Glaser (1985) and Baron and Sternberg (1986) contain more information on commercial programs. A number of commercial programs are based on the theories of Piaget, Bloom, Guilford, and Gagne.

Independent vs. integrated approaches. The teaching of thinking is typically incorporated into the curriculum in two ways: (a) It is taught as an independent subject, or (b) it is integrated into a subject area. American models typically incorporate the teaching of thinking into one or more subject areas. The rationale is that subject matter gives purpose to thinking and that what is required to be an effective thinker in one subject area may not be helpful in another. Using the other approach, de Bono (1983) developed the Cognitive Research Trust (CoRT), which is based in Cambridge, England. DeBono argues that when students are discussing content, they are not thinking about the thinking that they are using to discuss the subject. In other words, attending to content distracts from attending to the thinking tools being used. Therefore, he believes that a specific place in the curriculum should be set aside for teaching thinking skills. Rosen (1986) investigated the short-term effects of critical thinking instruction upon low-ability students in ninth grade. One group was taught critical thinking as a separate subject; one received critical thinking instruction as an integral part of the curriculum; and a third was provided critical thinking lessons as an enrichment opportunity. No significant differences were reported.

Teacher behavior and student achievement. Research generally supports the relationship between the critical thinking ability of teachers and student behavior and achievement. Hunt and Germain (1969) reported that teachers who evidenced high critical thinking ability themselves gave students more opportunities to use higher level thinking processes than teachers low in critical thinking ability. Measel and Mood (1972) found a relationship between the level of thinking inherent in teachers' verbal behavior and the level of thinking of their students. James (1986/1987) reported that direct instruction and guided practice in question generating influenced students' higher level thinking skills.

Redfield and Rousseau (1981) used a meta-analytic technique to synthesize 14 experimental research findings on the relationship between teacher questioning and student achievement. The analysis demonstrated that the predominant use of higher cognitive questions by teachers had a positive effect on student achievement.

Based on Piaget's description of the development of thinking proceeding from the concrete to the abstract and Gagne's concept of hierarchical sequencing, Armstrong and Armstrong (1987) developed an inservice program for helping teachers ask questions to facilitate higher order thinking skills among eighth grade students. The questioning strategy encouraged inductive reasoning by utilizing concrete stimuli to help students visualize the concept being taught. The questioning strategy led students to formulate the appropriate generalizations. Students in the treatment group averaged about 23% higher than the control group on test scores of academic achievement and critical thinking.

Not all research has shown such a strong positive correlation between teacher behavior and student achievement. An evaluation of the Questions to Upgrade and Encourage Student Thinking (QUEST) program indicated that while students of participating teachers did not vary significantly from the control group in achievement test scores, they were better able to give oral explanations of the reasoning behind their test responses (Hughes, 1981). Elrod (1979) reported that teachers' critical thinking ability and teachers' frequency of oral expressions of logic were not related to students' critical thinking ability or geometry achievement.

Garmston (1985) and Bellanca (1985) point out that some teachers who have never had preservice or inservice training in critical thinking are teaching thinking strategies. These teachers have probably helped their students take only the first step in the metacognitive process. Although the students are thinking, they are generally unaware of how they arrive at their conclusions. In other words, they need to be analyzing their conclusions, which is the second step in the metacognitive process.

> If students need to be taught tactics for thinking, then teachers must possess a repertoire of thinking strategies. . . . It is by increasing their own competence in thinking strategies that teachers can significantly affect the level of thinking in their students. (Heintschel, 1986, p. 3)

Heintschel goes on to say that "Teachers themselves become more skillful thinkers as they examine and model ways of teaching their students to think" (p. 10). The effect, therefore, becomes cyclical.

Summary

The need to teach thinking skills is generally accepted as is the premise that teachers must have a repertoire of thinking strategies themselves before they can begin to share them with students. Research has identified a relationship between teachers' use of critical thinking skills and students' scores on critical thinking tests and achievement tests. However, most teachers do not do any direct teaching of thinking, presumably because they do not know how. Therefore, providing staff development activities which will engage teachers in thinking strategies which they can pass on to their students seems crucial. Research suggests that the direct teaching approach is equally appropriate for inservice teachers and students.

The effectiveness of computers in improving achievement scores through drill and practice activities has been established. It has been suggested that the unique capabilities of computers will make them even more valuable in the teaching of critical thinking, but there has been little research to substantiate this claim.

Commercial staff development programs typically measure gains made by students after their teachers have received instruction in some aspect(s) of critical thinking. The literature does not describe changes in teachers' thinking after receiving training in critical thinking. Will the thinking skills of teachers who participate in a critical thinking workshop be fairly similar or vary widely? Will there be significant changes in their thinking skills after receiving the workshop treatment? Will the teachers whose own scores showed the greatest gain be the ones whose students subsequently show the greatest gain?

CHAPTER III

PROCEDURES

Research Design

This research was a two-group, pretest-posttest randomized experimental design. Each group consisted of 10 teachers and their middle school students. Both groups of teachers participated in a 10-hour workshop in which they learned how to teach critical thinking. The treatment group received instruction on the use of computer programs in addition to other activities and materials for teaching critical thinking. The control group was only given instruction on the use of traditional methods for teaching critical thinking.

Selection and Description of Subjects

Subjects included all the fifth and sixth grade classroom teachers and their students at one middle school in rural Piedmont North Carolina. Twenty inservice teachers were randomly assigned to one of two groups. The treatment group, called the "computer group," consisted of 10 teachers (5 at the fifth grade level and 5 at the sixth grade level) who used computers in addition to traditional methods to teach critical thinking skills. The control group of 10 teachers (5 at the fifth grade level and 5 at the sixth grade level) used only traditional methods (i.e., paper and pencil, overhead projector, games, and group activities) to teach critical thinking skills. All students in the school received instruction in critical thinking, but scores of the 49 students who were absent for either the pretest or the posttest were not included in the data analysis. Data were analyzed for 449 students. This included 246 fifth grade students and 203 sixth grade students. A total of 239 students were in classrooms with computers while 210 students were in classrooms without computers.

Permission to teach and to test the students for critical thinking was granted by the principal and the superintendent of schools. Before the pretests were administered, parents of each student received a letter from the principal (Appendix A) explaining the purpose of the project.

Written consent to participate in the project (Appendix B) was obtained from the teachers in the workshop. These teachers were informed about (a) the nature of the study, (b) the benefits to them and their students, (c) the confidentiality of the collected data, and later, (d) the results of the study.

Workshop

Teachers were required to devote 10 contact hours to the workshop for which they received 1 hour of certificate renewal credit. Teachers were asked to provide at least

30 minutes per week of classroom instruction in critical thinking skills as they were presented at the workshop and to provide at least 1 hour per week per student for reinforcement or practice of skills. In the classrooms with computers, teachers were asked to schedule at least 30 minutes per week per student to use the computer software for teaching critical thinking. This computer time was part of the required 1 hour of weekly practice in skills. Teachers were encouraged to spend as much time on thinking skills as they felt they could and to use supplementary materials from other sources.

The workshop consisted of eight sessions which lasted an average of 1 hour and 15 minutes. The syllabus (Appendix C) included the following: (a) pretest, (b) teaching thinking skills, (c) deductive thinking strategies, (d) syllogisms, (e) inductive thinking strategies, (f) credibility, (g) assumption identification, and (h) posttest.

Since the computer software primarily reinforced deductive and inductive thinking skills, the computer and noncomputer groups met separately the weeks that those two topics were covered. The computer group was shown how to use the software and how to incorporate it into lesson plans as a means of reinforcement. The noncomputer group was given traditional reinforcement activities which could be used by the whole class, by small groups, or by individuals.

In all of the workshop sessions a direct teaching approach was used. The leader presented the material to the workshop participants as she would have presented it to middle school students. Three stages were emphasized in each lesson plan: (a) the concrete stage which employed concrete examples or drew upon past experiences, (b) the semiconcrete stage which used graphic representations (including the computer for that group) to reinforce thinking skills, and (c) the abstract stage at which students used pencil and paper to solve problems or arrive at conclusions.

Software

Two software programs were selected for classroom use. Mind Benders (Harnadek, 1988) was used to develop deductive reasoning skills. Students solved word problems using a matrix which helped organize the information deduced from the clues. The Factory (Kosel & Fish, 1983) was chosen to promote inductive reasoning skills. Students designed a factory assembly line to produce the desired product.

Instruments

Cornell Critical Thinking Tests, Level X and Level Z

The basic instruments for measuring outcome were the Cornell Critical Thinking Test, Level X, which was designed for students in Grades 4 through 14 and the Cornell Critical Thinking Test, Level Z, which was designed for adults. Level X included 76 multiple choice items. Level Z had 52 items. Each item on each test had three choices, one of which was the keyed answer. Subjects were given 1 hour to complete each test.

The operational definition of critical thinking used in this study was "the process of reasonably deciding what to believe and do" (Ennis et al., 1985, p. 1). Aspects of critical thinking measured by Level X and Level Z include:

1. Induction or drawing conclusions uses best-explanation criteria. The hypothesis about a best-explanation is supported (a) by its ability to explain facts, (b) by its plausibility, (c) by its being consistent with the facts, and (d) by the inconsistency of competitors with the facts (Ennis et al., 1985, p. 24).
2. Credibility involves judgments about whether and to what extent to believe someone else's assertion if the one judging has no direct access to the basis for the assertion (Ennis et al., 1985, p. 25).
3. Deduction or conditional propositions in reasoning refer to arguments which contain the "if-then" premise in which the truth of Condition B depends on the truth of Condition A (if A then B). The "if" part of an "if-then" statement is the antecedent, and "then" is the consequent (Ennis et al., 1985, p. 26).
4. Assumption identification is defined as choosing a statement which fills a gap in the reasoning more completely than the other choices (Ennis et al., 1985, pp. 26-27).

Two methods were employed to estimate the reliability of the Cornell Critical Thinking Tests. The Spearman-Brown method estimated a reliability from .76 to .87 on Level X and .55 to .76 on Level Z. The Kuder-Richardson approach gave a reliability estimate from .67 to .90 on Level X and from .50 to .77 on Level Z.

The validity of these tests is the extent to which they actually measure critical thinking. Criterion validity is not appropriate here because there is no established criterion for critical thinking ability.

Content validity was established when members of the Illinois Critical Thinking Project agreed that the items and the coverage were significant and the answers were defensible. The authors pointed out that "there is no definitive establishment of the construct validity of any critical thinking test" (Ennis et al., 1985, p. 22).

The Cornell Critical Thinking Tests were deemed suitable by the authors for detecting differences in critical thinking between groups. These tests were recommended as a means of determining whether a particular instructional approach was effective by comparing instructed and uninstructed groups. A control group was considered to be necessary in order to draw conclusions about the effect of the instructional approach (Ennis et al., 1985, p. 23).

<u>Teacher Questionnaire</u>

The teacher questionnaire (Appendix D) obtained three variables: grade level taught, years of teaching experience, and degrees held.

Interview Questions

Teachers were questioned about the types of thinking activities used in the classroom and the amount of time spent on those activities (Appendix F).

Data Collection

The Cornell Critical Thinking Test, Level Z, was given as a pretest and as a posttest to determine gains in critical thinking skills of teachers participating in the study. The Cornell Critical Thinking Test, Level X, was administered to students as a pretest at the beginning of the fall semester and as a posttest at the end of the 9-week teaching period to determine gains in critical thinking skills of students. A person trained by the researcher administered the tests. Answers were scored by machine. Scores of students who were absent for either the pretest or the posttest were not included in the data analysis.

Gain scores of the treatment group of teachers were compared with the control group. Likewise, gain scores of students of the treatment group of teachers were compared with the gain scores of the students of the control group. Also, teachers' gain scores were compared with students' gain scores. Variance in teachers' gain scores were analyzed for influence of learning the computer programs, years of teaching experience, degrees held, and teaching strategies employed. Variances in student gain scores were analyzed for influence of computer use, grade level, California Achievement Test scores (i.e., science, reading, math, and total scores), Test of Cognitive Thinking scores, and placement in resource classes (i.e., academically gifted, reading lab, and learning disabled).

Teachers completed a questionnaire which asked for grade level taught, years of teaching experience, and degrees held (Appendix D). The researcher explored possible relationships between these variables and thinking scores of teachers and students.

Teachers also kept a log of critical thinking activities and materials used each week during the 9-week treatment period (Appendix E). The logs were used by the researcher to analyze teaching strategies.

Teachers were interviewed (Appendix F) to determine the approach used in teaching new thinking skills, the amount of time spent on various activities, and the emphasis placed upon whole class, small group, and individual involvement in the activities.

California Achievement Test scores (i.e., science, reading, math, total score, and Test of Cognitive Skills) were gathered for a random sample of 100 students to determine which variable was the best predictor of critical thinking scores.

Analysis of Data

Pretest scores were used to assure group equivalence. A *t* test was calculated to determine whether there was a significant difference at the .05 level between the means of the pretest, posttest, and the gain scores of the treatment groups and the control groups. Analysis of variance was used to determine which independent variable was the best predictor of the dependent variable. Therefore, the following analyses were employed:

1. A *t* test for pretest and posttest scores for teachers using computers.
2. A *t* test for pretest and posttest scores for teachers not using computers (the control group).
3. A *t* test for gain scores for teachers using computers and teachers not using computers.
4. A *t* test for pretest and posttest scores of students using computers.
5. A *t* test for pretest and posttest scores of students not using computers (the control group).
6. A *t* test for gain scores of students using computers and students not using computers.
7. Descriptive statistics for student gain scores by classroom.
8. A *t* test for gain scores of students for grade level (Grade 5 or Grade 6).

9. A multiple regression of California Achievement Test scores (i.e., science, reading, math, total score, and Test of Cognitive Skills) to predict gain scores in critical thinking.

Summary

The method of study in this research project was a pretest and posttest data analysis designed to determine the effectiveness of computers in teaching thinking skills in fifth and sixth grade classrooms. The criterion measure was the Cornell Critical Thinking Test, Level X and Level Z. This instrument was chosen because comparable skills were measured for adults and students. Therefore, gains in teachers' thinking skills could be compared with gains in students' thinking skills.

CHAPTER IV

RESULTS AND DISCUSSION

Data were collected in this study in order to investigate the effectiveness of computer technology in developing critical thinking skills of teachers and middle school students. The influences of years of teaching experience and educational degrees held by the teacher upon teacher gains and student gains in critical thinking were also investigated. In addition, this study examined the relationship between achievement test scores and critical thinking scores.

Data Analysis

The treatment groups in this study included 10 teachers and 239 students who had computers in the classroom. The control groups consisted of 10 teachers and 210 students who did not have computers in the classroom. There was no significant pretest difference between the treatment group of teachers ($\overline{x}$ = 28.6) and the control group ($\overline{x}$ = 28.7). There was also no pretest difference between the treatment group of students ($\overline{x}$ = 36.5) and the control group ($\overline{x}$ = 35.6). The assumption was that the treatment groups and the control groups were the same prior to the treatment.

Computer Technology Versus Traditional Methods

A major hypothesis in this research was that teachers who were taught to use computers in the classroom for critical thinking would have higher gain scores on a critical thinking test than teachers who were taught to use traditional methods. Likewise, the students of the treatment group of teachers were expected to have higher gain scores than the students of teachers in the control group. Gain scores on the posttest from the pretest on critical thinking were computed for each group of teachers and students. (See Table 1.)

The data used to test the major research hypothesis were the Cornell Critical Thinking Test, Level Z, pretest and posttest scores. A *t* test for paired samples was computed to determine if there was a significant difference at the .05 level between pretest and posttest scores.

It was further hypothesized that teachers and their students would show similar gains. From Table 1 the evidence is not clear. While teachers of fifth graders in the computer group showed no significant gain, their students did show a significant gain in critical thinking scores. Both sixth grade teachers and students in the computer group had substantial gain scores. While the noncomputer groups of teachers showed no significant gain, the sixth grade students in the noncomputer group had the highest gain scores of all. Therefore, there was not a similar gain between students and teachers, and the hypothesis was not supported.

Table 1

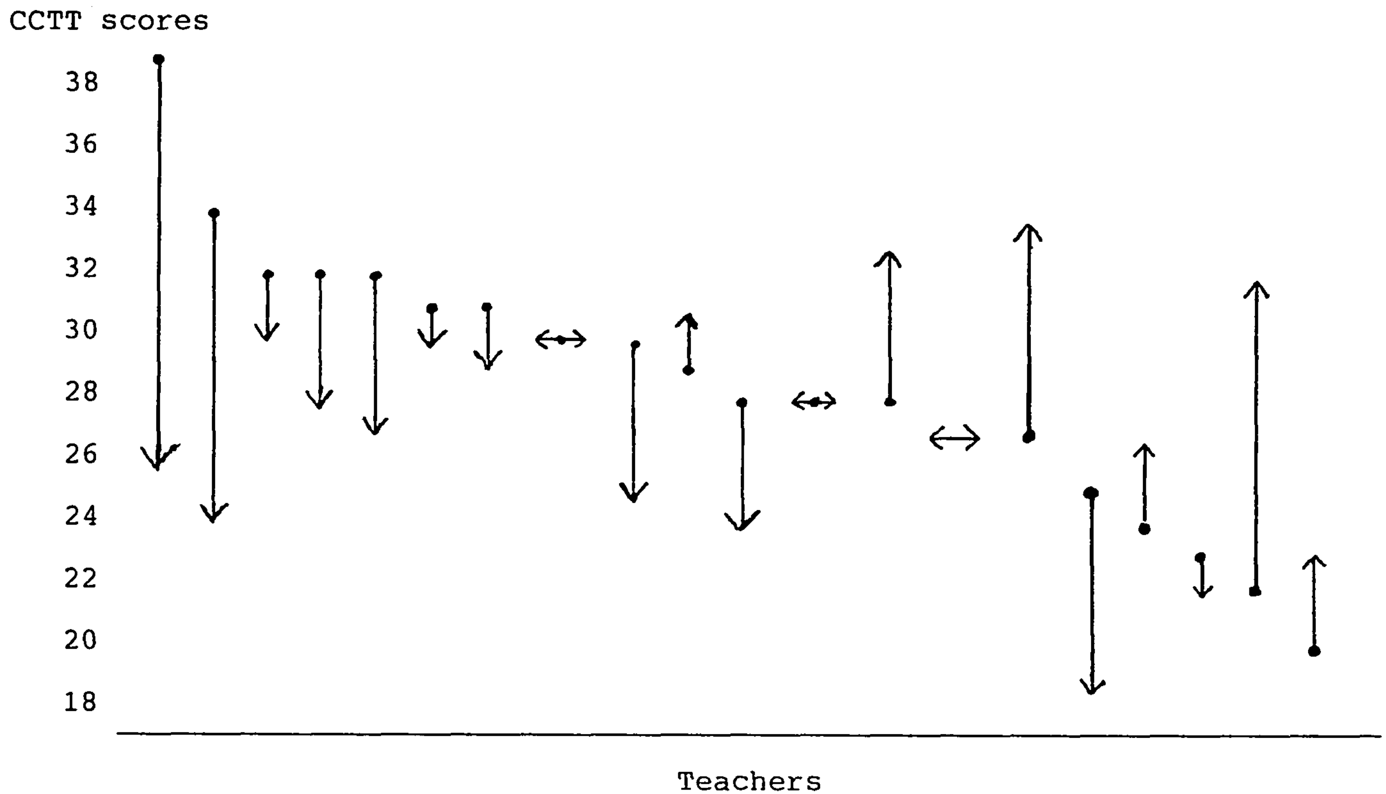
Results of a *t* test for Mean Gain Scores on Critical Thinking between Classrooms with and without Computers

Method of Teaching							
With Computer				Without Computer			
Teachers		Students		Teachers		Students	
-0.66		2.6**		-1.7		2.2**	
5th	6th	5th	6th	5th	6th	5th	6th
-4.2	3.25	2.81*	2.46	-2.8	-0.6	0.69*	4.18

*significant at the .02 level
**significant at the .0001 level

Staff Development

It was expected that teachers' posttest scores would be significantly different from pretest scores after receiving instruction in a thinking skills workshop. Although no specific attempts were made at the workshop to "stretch" the critical thinking of the teachers themselves beyond understanding what thinking skills their students could reasonably be expected to master, it was anticipated that teachers' own critical thinking skills would grow along with the skills of their students as they engaged in the assigned activities. However, it appears that before the workshop began, the critical thinking skills of the teachers as a group had progressed well beyond what was expected of the students. Posttest scores of teachers suggest regression toward the mean. "That is, on the average, examinees tend to deviate only 60% as much from the posttest mean as they did from the pretest mean" (Glass & Hopkins, 1984, p. 128). Generally, the teachers with pretest scores above the mean had lower scores on the posttest, while teachers with pretest scores below the mean showed higher posttest scores. Figure 1 illustrates this phenomenon. The arrows pointing downward represent decreased scores on the posttest. Arrows pointing upward represent increased scores on the posttest. Horizontal arrows indicate that pretest and posttest scores were the same. One teacher took only the posttest.



. = pretest score ($\overline{x}$ pretest = 28.68)

↓↑ = posttest score ($\overline{x}$ posttest = 27.45)

↔ = posttest only score

↔ = same score for pretest and posttest

Figure 1. Teachers' pretest and posttest scores on CCTT.

A t test was used to compare differences in the means of the gain scores (posttest minus pretest scores). Results of the t test revealed a mean gain of -1.21 which was not statistically significant. Therefore, the hypothesis was not supported.

Effects of Teacher Experience and Education

Years of experience were not expected to significantly influence teacher gain scores or student gain scores. A Pearson correlation revealed no significant relationship for years of experience with teacher gain (r = .23), but there was an inverse relationship between years of teaching experience and student gain (r = -.60) which was significant at the .005 level. Students of teachers with the fewest years of experience had the highest gain scores. Therefore, the hypothesis was partially supported.

Educational degrees were not expected to significantly influence teacher gain scores or student gain scores. Four teachers in the sample of 20 held Master's degrees. Results of this analysis indicated that educational degrees held by the teacher were not significantly related to teacher gain (r = .26) or student gain (r = -.08). Therefore, the hypothesis was supported.

Student Achievement Scores

Results of a t test for students' gain scores indicated that in addition to overall gains, students made significant gains in deductive reasoning, inductive reasoning, and assumption identification. (See Table 2.)

Since achievement test scores also indicate intellectual skill, the California Achievement Test (CAT) scores were compared with scores on the Cornell Critical Thinking Test (CCTT). A random sample of 100 students was selected to examine the relationship between CAT scores and CCTT scores. Subtests of the CAT which were included as variables were science, reading, and math. The test of Cognitive Skills score was also included as a variable.

It was expected that CAT scores would be significantly related to gains made by students on the CCTT. The results of a regression analysis indicated that for all students in the sample ($n = 100$), the CAT reading score was the best predictor of both overall gain scores ($p < .03$) and gains in deductive reasoning scores ($p < .04$) on the CCTT. At the fifth grade level total CAT scores were the best predictor of overall pretest scores ($p < .01$) on the CCTT and pretest credibility scores ($p < .01$) on the CCTT. For fifth graders science scores on the CAT also predicted overall pretest CCTT scores ($p < .02$) and overall gain scores ($p < .05$). Math scores on the CAT predicted overall pretest scores ($p < .03$), pretest credibility scores ($p < .01$), and credibility gain scores ($p < .04$) for fifth graders. At the sixth grade level science scores on the CAT predicted pretest

Table 2

Results of a *t* test for Students' Overall and Subtest Gain Scores

Variable	*n*	mean	std error	*t*	prob
overall	449	2.448	9.3339	7.329	.0001
deductive	449	1.641	0.2050	8.005	.0001
credibility	449	0.263	0.1475	1.782	.0754
inductive	449	0.552	0.1815	3.043	.0025
assumption	449	0.693	0.1087	6.374	.0001

scores in assumption identification ($p < .05$), while reading predicted pretest inductive reasoning scores ($p < .01$). There was no significant relationship between Test of Cognitive Skills scores and CCTT scores at either grade level.

The hypothesis that CAT scores would be significantly related to gain scores was supported. For all students in the sample, the CAT reading score was the best predictor of overall gain. For fifth garders science scores on the CAT also predicted overall gain scores.

Students in Gifted, Reading, and Learning Disabled Classes

The gain scores of students in resource classes, when analyzed separately, varied somewhat from those of the larger population. Table 3 shows the results of a paired t test for nonindependent samples on gain scores for all students at each grade level as well as for students in academically gifted (AG) classes, in the Chapter I reading program, and in the classes for the learning disabled (LD).

At the fifth grade level all groups of students with a computer showed greater gains than those without. In Grade 6 the AG students without computers achieved a greater gain than those with computers, thus establishing a trend which was not statistically significant for the total population of sixth graders. Only the LD students showed greater gains with a computer at the sixth grade level.

Table 3

Results of a *t* test for Students' Mean Gain Scores by Grade Level

	n	All	*n*	AG	*n*	Reading	*n*	LD
Grade 5								
computer	128	2.81**	22	3.91*	21	3.14	9	3.89
without	118	0.69**	16	2.69*	25	-.92	4	-6.75
Grade 6								
computer	111	2.46	19	3.16***	18	1.89	13	5.38*
without	92	4.18	23	4.52***	11	2.82	8	3.13

*significant at the .05 level.
**significant at the .02 level.
***significant at the .01 level.

Discussion

Computers and Critical Thinking

In this study a direct approach to teaching critical thinking was modeled at an inservice workshop. Specific thinking skills were introduced by using concrete objects and/or by drawing on prior experience. Suggested materials and activities for reinforcement of those skills at the semiconcrete or graphic representation level were then presented. Finally, suggestions were made for applying those skills at an abstract level. Two computer programs (one using a deductive approach to problem solving and one using an inductive approach) were presented to the 10 teachers who had computers in their classrooms as a strategy for reinforcing reasoning skills at the semiconcrete level. Each student was to have at least 30 minutes of computer time each week.

Overall, students with computers showed a mean gain of 2.6 while students without computers showed a mean gain of 2.21. This difference was significant at the .0001 level. However, computers played a more critical role in the development of thinking skills at the fifth grade level than at the sixth. The mean gain for fifth grade students with a computer was 2.81, while the mean gain for students without a computer was 0.69. This was congruent with results of a study by Lance (1986) who compared the thinking strategies of fifth grade students who were exposed to print stimuli and to computer stimuli. In that study, computers stimulated a greater number of thinking strategies.

At the sixth grade level students without computers had a greater mean gain (4.18) than students with computers (2.46), but the difference was not statistically significant. Sixth grade results were similar to those reported by Perkins (1985) in a project involving seventh graders. In the Perkins study, a 9-week course in critical thinking included one treatment group receiving traditional instruction and another using computer software with the same instructional objectives. A control group received no form of instruction in critical thinking. Perkins reported no significant differences among the three groups.

The evidence suggests that fifth grade students, who are 10 or 11 years old and just moving out of the concrete operational stage, still rely heavily on graphic representations such as those provided by a computer. However, sixth grade students, who are 11 or 12 years old and moving into the stage of formal operations, have become more proficient in dealing with abstractions. Graphic representations, such as those provided by computers, may become less important at this stage. The fact that, in this study, sixth grade students with a computer did show a gain in overall thinking skills, although not as great as the gain of those without computers, suggests that developmentally some sixth graders, perhaps the younger ones, are still making the transition to the formal operational stage.

Staff Development

The inservice workshop was designed to help teachers promote the critical thinking skills of middle school students. Materials and activities, including computer software, were aimed specifically at students moving developmentally from what Piaget described as the concrete operational stage to the formal operational stage (Wilgard & Atkinson, 1967).

It was anticipated that teachers' own critical thinking skills would grow along with the skills of their students, but no specific activities were provided at the workshop to promote the critical thinking of teachers themselves. In retrospect, it seems more logical to assume that teachers' thinking, which was developmentally beyond that of the stage targeted by this workshop, would not be significantly affected by materials and activities designed for 10- to 12-year-olds. In order to promote the critical thinking of adults, a workshop focusing on more complex skills would be in order.

Another possible explanation was the generally unfavorable attitude of the teachers toward being tested and/or the test itself. Workshop participants expressed positive feelings toward the workshop and seemed eager to share thinking activities with the students, but resisted taking the test themselves. Some indicated that it was a waste of time; others questioned the ability of the instrument to measure their thinking skills. This reaction to testing suggests the need for a less obtrusive way to evaluate teacher thinking.

<u>Teacher Experience and Education</u>

Teacher experience was not expected to influence teacher gain scores or student gain scores. A Pearson correlation revealed no significant relationship for years of experience with teacher gains, but there was a significant ($p < .005$) inverse relationship between years of teaching experience and student gain scores. An overview of the four classrooms showing the greatest gains in student thinking scores revealed that teaching experience for the four teachers ranged from 3 to 6 years. The range for the 20 teachers in the sample was 3 to 28 years with a mean of 13.2 years. The top eight classrooms in the study had only one teacher with more than 10 years of experience, and that teacher had recently completed a master's degree. In other words, the teachers in this study who had most recently been in school themselves had students with the greatest gains in critical thinking scores. It is assumed that in recent years teachers' colleges have placed greater emphasis upon teaching thinking skills.

Educational degrees held by the teacher were not expected to influence teacher gain scores or student gain scores, and this was confirmed by a correlational analysis. Four of the 20 teachers in the study held master's degrees. Gain scores for the four teachers with master's degrees ranged from 0 to -13. The range for the 20 teachers in the sample was from -13 to 10. Their students' gain scores ranged from -1.04 to 6.4. The mean gain for all students was 2.4.

Student Achievement Scores

It was expected that CAT scores would be significantly related to gains made by students. The results of a regression analysis indicated that for the 100 students in the sample, the CAT reading score was the best predictor of overall gain scores ($p < .03$) on the CCTT. For fifth graders science scores on the CAT predicted overall gain scores ($p < .05$). The CAT was less predictive at the sixth grade level than at the fifth.

Critical Thinking Skills between Classrooms

Mean overall gain scores for the 20 individual classrooms ranged from -1.04 to 6.4. Mean raw overall scores on the pretest for classrooms ranged from 30.25 to 43; posttest scores ranged from 32.25 to 44.69 with a mean overall gain of 2.4.

<u>Classrooms with the highest gain scores</u>. An overview of the four classrooms with the highest overall gain scores, which ranged from 4.25 to 6.4, revealed a number of similarities. In each of these classrooms the most significant gains on specific reasoning skills were made in deductive reasoning. Three of the four classrooms also made significant gains ($<.05$) on one other thinking skill (i.e., induction, assumption identification, or credibility). In the fourth classroom scores approached significance on two other thinking skills ($<.06$ on inductive reasoning and $<.07$ on assumption identification).

All four were sixth grade classrooms. One of the four classrooms had a computer. Because some teachers had lower posttest scores than pretest scores on the Cornell Critical Thinking Test (CCTT), pretest and posttest scores were averaged for ease of comparison. Therefore, the four teachers' averaged scores on the CCTT ranged from 27 to 31, while the range of averaged scores for all 20 teachers in the sample was 21.5 to 31. One of the four teachers had a master's degree. Teaching experience for the four ranged from 3 to 6 years.

Teachers' logs (Appendix E) and interview questions (Appendix F) were used to identify patterns in teaching styles and critical thinking activities employed in the classrooms. Teachers in the four classrooms with the highest gain scores began by teaching thinking skills directly and in isolation from content areas. Self-reports indicated that they not only used all workshop materials but added to them. They acquired materials from other sources as well to reinforce the specific thinking skill being taught. Thinking activities in the content areas were fewer in number and were introduced only after specific skills were judged by the teacher to be well understood by most of the students. This was congruent with Beyer's (1987) observation that in the early stages of developing a new skill, it seems better to concentrate on thinking as the subject matter to be learned. Eventually, a new skill can be applied to other areas.

One of the four teachers worked primarily with the whole class on thinking activities; the others frequently assigned their students to small groups for cooperative learning sessions. The one classroom in the four that had a computer also had the highest overall mean gain scores (6.4). That teacher reported using the computer for reinforcement but did not depend on it to introduce a given skill.

Classrooms with the lowest gain scores. An overview of the four classrooms with the lowest gain scores revealed fewer similarities. Overall gain scores in this group ranged from -1.04 to 0.50 compared with 4.25 to 6.4 for the four classrooms with the highest gain scores. Three of the four classrooms showed their greatest gain in inductive reasoning; the fourth showed its greatest gain in assumption identification. However, none of these gains were statistically significant. This group included three fifth grade classrooms and one sixth grade classroom. The sixth grade classroom had a computer. Teaching experience for the four teachers ranged from 9 to 19 years. One teacher had a master's degree. Teachers' averaged thinking scores ranged from 29 to 30.5 compared to the range of 22.5 to 30.5 for all 20 teachers.

These teachers used most or all of the materials presented at the workshop and emphasized thinking skills suggested in the content areas. According to self-reports, many critical thinking activities suggested in reading, mathematics, science, and social studies texts were employed throughout the treatment period. Activities generally involved the whole class working together or students working individually to solve a problem.

Classrooms with scores nearest the mean. Still fewer similarities existed among the classrooms whose overall gain scores were nearest the population mean. The mean classroom gain ranged from 1.32 to 3.63. Of the 12 classrooms with scores nearest the mean, 7 were at the fifth grade level and 5 were at the sixth grade level. Eight of the 12 classes in this group (5 at the fifth grade level and 3 at the sixth grade level) had computers. Teaching experience ranged from 4 to 28 years. Two teachers had master's degrees. The eight teachers' averaged critical thinking scores ranged from 21.5 to 30.5, which was also the range for the total sample of 20 teachers.

Six of the 12 middle classrooms made significant ($<.05$) gains in deductive reasoning, 2 made significant ($<.05$) gains in inductive reasoning, and 5 made significant ($<.05$) gains in assumption identification.

Self-reports indicated that the teachers in this middle group struck a balance between the amount of time spent on activities suggested at the workshop and on thinking activities suggested in the content areas. Teachers who had computers reported that students spent about as much time at the computer as engaged in other thinking activities. Most teachers worked with the class as a total group, although some broke their classes into smaller groups for a particular activity. Some assigned extra thinking activities or computer time to students who had finished their daily work.

Generally, classrooms in the middle group which were above the population mean tended to be similar to the classrooms in the top group, in that direct teaching strategies were generally employed and more emphasis was placed on workshop materials than on critical thinking activities linked to the content areas. However, fewer activities which dealt with thinking as a separate subject were reported by teachers in the middle group. Likewise, classrooms in the middle group whose overall scores were below the population mean tended to be similar to the classrooms with the lowest scores. Self-reports indicated that these teachers made a real effort from the beginning of the 9-week treatment period to employ thinking skills in the content areas.

Students in Gifted, Reading, and Learning Disabled Classes

At the fifth grade level all groups of students with a computer showed greater gains than those without. However, this difference between computer and noncomputer groups was not as great for the AG students as for all fifth grade students, suggesting that they may have been developmentally more mature and moving into the formal operational stage before others in their grade. Although the differences were not statistically significant, fifth grade reading students and LD students showed the greatest variation in gain scores between those with a computer and those without. LD students with a computer showed higher mean gain scores than any other group in fifth grade and greater negative scores than any other group without computers, suggesting that the kind of reinforcement provided by the computer was most helpful to them. The pattern for reading students was similar but less pronounced.

In Grade 6 the AG students without computers achieved a greater gain than those with computers, thus establishing the trend which was not statistically significant for the total population of sixth graders. Presumably, the AG students were developmentally well into the formal operational stage with less need for the kind of reinforcement provided by the computer programs in this study. The reading students made less progress with the computer than without, but the difference was less than for the total population of sixth grade students. Only the LD students showed greater gains with a computer at the sixth grade level, suggesting again that the computer was most helpful for students still functioning at or nearer to the stage of concrete operations.

The relationship of computers to gains in thinking scores among fifth grade students in general and LD students in particular raises questions as to why. Did the computer serve only as a motivating variation from the traditional kinds of classroom practice? More specifically, was the graphic representation of thinking skills provided by the computer the critical feature? Did the computer's positive feedback provide the self-assurance required to tackle more difficult thinking problems?

Summary

Data were collected in this study in order to determine the effectiveness of computer technology in developing the thinking skills of middle school teachers and students. Results indicated that while students in this study showed a significant gain in critical thinking scores, teachers did not. When differences between computer and noncomputer groups were compared, there were significant differences for students but not for teachers. When differences between grade levels were investigated, fifth grade students with computers showed a significant gain in critical thinking scores. At the sixth grade level, LD students with computers showed a significant gain in critical thinking scores. CAT scores were more predictive for fifth grade than for sixth. An overview of classrooms based on teachers' logs and interview questions suggested that teachers in the classrooms with the highest gain scores treated critical thinking as a separate subject, used a direct approach in teaching critical thinking skills, frequently employed a cooperative learning approach, and used the computer for reinforcement but did not depend on it to teach.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

A major purpose of this study was to determine the effectiveness of computer technology in developing the critical thinking skills of middle school teachers and their students. The subjects included 20 classroom teachers and 449 fifth and sixth grade students in a public school in rural Piedmont North Carolina. This included 10 teachers and 239 students who had computers in the classroom and a control group of 10 teachers and 210 students who did not have computers in the classroom. The 10 teachers in the computer group (5 at the fifth grade level and 5 at the sixth grade level) used computers in addition to the other activities and materials presented at a staff development workshop. These 10 attended separate workshop sessions to learn to use the critical thinking computer programs. The other 10 teachers (5 at the fifth grade level and 5 at the sixth grade level) received instruction only in the use of traditional materials (i.e., paper and pencil, overhead projector, games, and group activities) and consequently used these materials in the control classrooms to teach thinking skills.

The inservice workshop consisted of eight weekly sessions (Appendix F), each of which lasted for 1 hour and 15 minutes. A direct teaching approach was employed in which the workshop leader modeled the strategies for teaching specific thinking skills. Each classroom lesson plan was built upon three stages suggested by Wirtz (1985): (a) the *concrete* stage employed concrete examples or drew upon prior experiences, (b) the *semiconcrete* stage used graphic representations, which in some classes were provided by a computer; and (c) the *abstract* stage used pencil and paper to arrive at conclusions.

The Cornell Critical Thinking Test, Level Z, was given as a pretest and as a posttest to determine gains in critical thinking skills of workshop participants. The Cornell Critical Thinking Test, Level X, was administered to students at the beginning of the fall semester and at the end of the 9-week instructional period to measure gains in thinking skills.

Other instruments used to gather data included a teacher questionnaire and a log of teaching activities. In addition, a short interview was conducted with each teacher.

Six directional hypotheses were formulated and tested by the research. Each hypothesis and the results are listed below:

1. Gain scores of teachers and students using computer technology will be significantly higher than gain scores of those using only traditional methods. The hypothesis was partially supported in that students working with a computer showed significantly higher gain scores than the control group, while teacher gain scores were not significant.
2. There will be a positive relationship between teacher gains in critical thinking and gains of their students measured by the Cornell Critical Thinking Test. The hypothesis was not supported.
3. Teachers' posttest scores on the Cornell Critical Thinking Test will be significantly different from pretest scores after a workshop utilizing computer technology. The hypothesis was not supported.
4. Number of years of teaching experience will not significantly affect teacher gain or student gain. A correlation analysis revealed no significant relationship between years of teaching experience and teacher gain scores, but there was a significant inverse relationship between years of teaching experience and student gain scores. Therefore, the hypothesis was partially supported.
5. Educational degrees held by the teacher will not significantly affect teacher gain or student gain. The hypothesis was supported.

6. California Achievement Test Scores will be significantly related to gains made by students in critical thinking. The hypothesis was partially supported in that reading scores on the CAT predicted overall gain scores and deductive reasoning scores for all students; science scores on the CAT predicted overall gain scores for fifth grade students; and math scores on the CAT predicted credibility gain scores for fifth grade students.

Conclusions

In comparing gain scores of the computer group with the control group (the students who did not have computers), the fifth grade students with computers showed a mean gain of 2.81 which was significant at the .02 level. Fifth grade students who attended special classes (i.e., AG, reading lab, and LD) also showed greater gains after working with a computer than did the control group. Sixth grade students in the control group showed higher gains than the students who had a computer, although the difference was not significant. Among the sixth grade students only the LD students with a computer scored higher than the control group. It was suggested that fifth grade students, who were 10 or 11 years old, may have been functioning primarily in the developmental stage described by Piaget as concrete operational and, therefore, benefitted most from the attributes of computer-aided instruction. On the other hand, sixth grade students, who were 11 or 12 years old, were moving into the formal operational stage of development and were better able to think abstractly without the graphic representations supplied by the computer. However, computer instruction in critical thinking appeared to be particularly beneficial to sixth grade LD students, who may still have been functioning in the concrete operational stage.

Educational degrees held by teachers were not significantly related to student gain in critical thinking, but there was an inverse relationship between years of teaching experience and student gain in critical thinking scores. An overview of the four classrooms which had the greatest overall gain revealed that those four teachers had taught 6 years or less. It was assumed that teachers' colleges have recently placed greater emphasis on teaching thinking skills than they had earlier.

An overview of classrooms based on teachers' logs of thinking activities and interview questions suggested that in the classrooms with the highest gain scores, teachers used a direct approach to teaching thinking and treated it as a separate subject to be learned. These teachers used not only the materials and activities presented in the workshop but found resources on their own to promote the development of specific skills. As suggested by Beyer (1987), thinking activities from the content areas were introduced in classrooms with the highest gains only when the teachers felt the students were ready to apply the skills which had been learned. While American models typically incorporate the teaching of thinking into one or more content areas, the approach of the teachers whose students showed the greatest gain in this study was consistent with that of DeBono (1983) who argues that when students are discussing content, it is distracting for them to try to think about their thinking. Therefore, application to content areas was limited and delayed in classrooms showing the greatest gain compared to other classrooms in the study. Conversely, teachers whose students showed the least gain reported using less direct methods of teaching and made early and repeated attempts to apply thinking in the content areas. Research (Ashby-Davis, 1984) has indicated that teachers frequently overestimate the ability of students to learn indirectly.

A random sample of 100 students was selected from the 449 to determine whether California Achievement Test (CAT) scores predicted scores on the Cornell Critical Thinking Test (CCTT). Subtests of the CAT which were included were science, reading, and math. The Test of Cognitive Skills was also included. The results of an analysis of variance indicated that the reading subtest on the CAT was the best predictor of overall gain scores on the CCTT at the .03 level of significance. For fifth grade students, total CAT scores were the best predictor of overall pretest scores ($p < .01$) on the CCTT. Fifth grade science scores on the CAT predicted overall pretest CCTT scores ($p < .02$) and overall gain scores ($p < .05$). CAT scores were less predictive at the sixth grade level than at the fifth.

Recommendations

The following recommendations are made for further development and study:

1. With the current emphasis upon teaching thinking in the public schools, there is a need to produce a sequential course of study which introduces a limited number of developmentally appropriate thinking skills at each grade level.
2. Textbooks in neary every content area are now including questions or activities at the end of most chapters and/or units entitled "Critical Thinking." It would be helpful to teachers to have these questions or activities categorized according to the kind(s) of thinking skill(s) involved and the level of difficulty. This would allow the teacher to quickly determine whether the students were ready for the skill. It would also help to "take stock" of whether the students were being exposed to a variety of thinking skills across the curriculum. It is important not to create another subject area entitled "Critical Thinking Skills."

3. Understanding the role of computers in teaching critical thinking would help administrators to make decisions about the most strategic placement of this technology. It appears that computers play a more critical role in teaching critical thinking at the fifth grade level than at the sixth. LD students with computers also made significant gains in critical thinking.
4. Inservice training for teachers should emphasize the appropriate use of computers in the classroom. In this study greatest gains occurred in classrooms where teachers introduced thinking skills as a separate subject, taught those skills directly, and used computers as one means of reinforcing and expanding the targeted thinking skills. Computers were not relied upon to do the teaching.
5. The reaction of teachers to testing suggests the need for less obtrusive ways to evaluate their critical thinking skills. The development of computer games where the scoring is not visible is a possible alternative.
6. Results of this study suggest that there is a difference developmentally between fifth and sixth grade students. The replication of this study at lower grade levels might reveal other important

differences in the ways children process information.

7. The greater gains made by students of teachers with fewer years of experience suggest a need for staff development for veteran teachers in the area of critical thinking. Results of this study indicate that training should be ongoing rather than limited to just a few sessions.

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APPENDIX A

LETTER TO PARENTS

EDEN CITY SCHOOLS

TELEPHONE 627-7068

INTERMEDIATE SCHOOL
609 COLLEGE STREET
EDEN, NORTH CAROLINA 27288

September 24, 1990

Dear Parents,

During this school year, students and teachers at Intermediate School will be participating in a project using computers to teach thinking skills. This project provides our students with two opportunities: (1) to become more proficient in the use of computers and (2) to begin to develop the kinds of thinking skills which they will eventually need to gain employment or to continue their education.

In the first stage of the project, which will begin in October, half of the students will receive computer instruction in the classroom and half will receive traditional instruction in thinking skills. In the second stage, the students who did not work with computers in the classroom will then do so. A test will be given to measure the effectiveness of the computer in teaching thinking skills.

In addition to the classroom activities described above, the computer lab will be in operation for all students for the development of other skills.

Sincerely,

Shirley M. Crisp

Shirley M. Crisp
Principal

APPENDIX B

CONSENT TO ACT AS A HUMAN SUBJECT

THE UNIVERSITY OF NORTH CAROLINA AT GREENSBORO

Consent to Act as a Human Subject
(Short Form)

Subject's Name ______________________________

Date of Consent ______________________________

I hereby consent to participate in the research project entitled Effects of Computer Technology and Traditional Methods of instruction upon the Critical Thinking Skills of Teachers and Students.

An explanation of the procedures and/or investigations to be followed and their purpose, including any experimental procedures, was provided to me by Lois P. Kezar ______________. I was also informed about any benefits, risks, or discomforts that I might expect. I was given the opportunity to ask questions regarding the research and was assured that I am free to withdraw my consent to participate in the project at any time without penalty or prejudice. I understand that I will not be identified by name as a participant in this project.

I have been assured that the explanation I have received regarding this project and this consent form have been approved by the University Institutional Review Board which ensures that research projects involving human subjects follow federal regulations. If I have any questions about this, I have been told to call the Office of Research Services at (919)334-5878.

I understand that any new information that develops during the project will be provided to me if that information might affect my willingness to continue participation in the project. In addition, I have been informed of the compensation/treatment or the absence of compensation/treatment should I be injured in this project.

______________________	______________________
Subject's Signature	Witness to Oral Presentation and Signature of Subject

If subject is a minor or for some other reason unable to sign, complete the following:

Subject is ____ years old or unable to sign because ______________________________

____

____
Parent(s)/Guardian Signature

APPENDIX C

WORKSHOP SYLLABUS

WORKSHOP SYLLABUS

Session 1 - Pretest

Session 2 - Teaching Thinking Skills
- What is critical thinking?
- Teacher behaviors and student achievement
- Developmental strategies for teaching thinking
- Elements of direct instruction

Session 3 - Deductive Thinking Strategies
- What is deductive reasoning?
- Using a matrix
- Examples of deductive reasoning

Session 4 - Syllogisms
- Following if-then rules
- Valid and invalid syllogisms

Session 5 - Inductive Thinking Strategies
- Making inferences
- Cause/effect relationships
- Drawing conclusions
- Supporting hypotheses

Session 6 - Credibility
- Common errors in reasoning
- Examining arguments and value judgments
- Evaluating semantic implications

Session 7 - Assumption Identification
- Reviewing the basic rules of logic
- What are assumptions?
- Avoiding jumping to conclusions

Session 8 - Posttest

APPENDIX D

TEACHER QUESTIONNAIRE

Teacher Questionnaire

Name____

Grade taught____

Number of years teaching experience_________________________

Degrees earned____

APPENDIX E

LOG OF CRITICAL THINKING ACTIVITIES

LOG OF CRITICAL THINKING ACTIVITIES

Name____

Week of October 1

Week of October 8

Week of October 15

Week of October 22

Week of October 29

LOG OF CRITICAL THINKING ACTIVITIES
(continued)

Name____

Week of November 5

Week of November 12

Week of November 19

Week of November 26

APPENDIX F

INTERVIEW QUESTIONS

INTERVIEW QUESTIONS

1. How did you go about teaching a new thinking skill?

2. How much time was spent on

   a. direct instruction using workshop activities?

   b. related activities from other sources?

   c. thinking activities suggested in content areas (i.e., science, math, social studies, reading, health)?

   d. the computer? (if applicable)

3. How much time was spent working

   a. with the whole class?

   b. in small groups?

   c. individually?