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The effect of critical thinking skills instruction on achievement and attitudes of elementary students differing in learning style preferences

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THE EFFECT OF CRITICAL THINKING SKILLS INSTRUCTION ON ACHIEVEMENT AND ATTITUDES OF ELEMENTARY STUDENTS DIFFERING IN LEARNING STYLE PREFERENCES

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by

Joan S. Byrne

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THE EFFECT OF CRITICAL THINKING SKILLS INSTRUCTION
ON ACHIEVEMENT AND ATTITUDES OF ELEMENTARY STUDENTS
DIFFERING IN LEARNING STYLE PREFERENCES

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CHAPTER 1

INTRODUCTION

The ability to think critically is an important issue in American education. Recent trends suggest that students perform much better on tasks requiring simple recall of information than on those requiring interpretative or inferential skills (NAEP, 1981). The emphasis on basic skills instruction in the past decade has focused on lower levels of cognitive thinking rather than higher level thinking skills as outlined by Bloom (1956, 1971). The increasing complexity of society and the continuing explosion of information suggest, however, that the ability to think critically is essential to and merits attention in the educational process.

In 1969 Ayelsworth and Regan urged the teaching of critical thinking in the classroom, instruction which had been largely missing for fifty years. Apparently it is necessary for this plea to be made again. It is probable that the ability to think critically does not occur spontaneously but must be learned and practiced.

Purpose

The purpose of this study was to determine the effect of teacher-paced versus self-paced instruction of critical thinking skills on the achievement of higher level thinking process and attitudes in elementary students with a high, moderate, or low preference for teacher-structured learning. The questions to be answered in the study were: (a) Can critical thinking skills be taught? (b) Does the methodology of teaching the skills affect achievement of higher cognitive processes? (c)

Does a match between the preferred learning style of the student and the teaching methodology make a difference in achievement of thinking skills? and (d) Is the attitude of students toward the instruction of critical thinking skills influenced by the teaching methodology or preferred learning style?

Hypotheses

The general hypothesis of the study was that the teaching of specific thinking skills to elementary students would result in greater achievement of higher level thinking, and further, by matching student learning style preference with a congruent teaching style, greater achievement and/or improved attitudes would be demonstrated. Six specific statistical hypotheses were outlined as follows:

Hypothesis H_0^1 states there is no significant difference in the achievement of higher level thinking skills of fifth grade students among teacher-paced instructional groups, self-paced instructional groups, and control groups.

Hypothesis H_0^2 states there is no significant difference in the achievement of higher level thinking skills between groups of students differing on levels of preference for teacher-structured learning.

Hypothesis H_0^3 states there is no significant interaction between treatment and preference on student achievement of higher level thinking.

Hypothesis H_0^4 states there is no significant difference in the attitudes of students toward the instruction of critical thinking skills between the teacher-paced and self-paced groups.

Hypothesis H_0^5 states there is no significant difference in the attitude of groups of students differing on levels of preference for

teacher-structured learning toward an instructional program in critical thinking skills.

Hypothesis H_0^6 states there is no significant interaction between treatment and preference in students' attitudes toward the instruction of critical thinking skills.

Definitions and Theoretical Rationale

What is critical thinking ability? Most definitions of critical thinking outline the process as a composite of skills which permit the individual to identify problems; select processes to analyze a problem; organize and classify information into a retrievable system of useful relationships; and use both inductive and deductive reasoning skills to work toward problem solutions. Analogously, intelligence as defined by Sternberg (1981) is a set of developed thinking and learning skills used in academic and everyday problem solving: problem identification, process selection, representation selection, processing allocation, solution monitoring, sensitivity to feedback, translation of feedback into an action plan, and implementation of the action plan. What is regarded or measured as intelligence involves the ability to think critically.

Can critical thinking be taught? There is some evidence to suggest that instructional programs focused on reasoning skills improve student performance in critical thinking (Hyram, 1957; Peel, 1973; Ward, Note 1). The selection of skills to be taught, the sample to be used, and the instructional plan to be developed were based on several theoretical models of cognitive function related to the study (Bloom, 1971; Guilford, 1966, 1968; Piaget, 1954, 1970). Levels of higher cognitive processes have

been defined by Bloom (1971) as processes which require the use of critical thinking skills. Guilford's "Structure of the Intellect" model (1966) suggests that intelligence is not a general ability but is a composite of multiple factors that can be taught as skills in the learning process. In Piaget's framework of cognitive thought development, individuals are able to think logically and more abstractly at approximately eleven to twelve years of age. It would seem appropriate, therefore, that the educational program provide some opportunity to enhance this process at the appropriate age. From the three theoretical models and related research, the skills of inductive and deductive reasoning and the classification of verbal and figural symbols were selected as key process in critical thinking strategies to be developed in eleven year old students.

Overview

What are some effective methodologies for teaching critical thinking skills? Although literature on the importance of teaching critical thinking abounds, and materials and programs for use in teaching the skills exist, there is little research documentation for comparing means for accomplishing the task. Direct instruction, however, has generally been shown to be more effective in teaching complex tasks (Soar, 1968, 1972) and was used in this study.

Self-directed learning is a frequently cited goal of education. Some research suggested that time-on-task, self-responsibility, and positive attitudes were increased when students were provided opportunities for regulating their own instruction (Arlin, 1975; Hannafin, 1981; Morris, Suber, and Bijou, 1978). Achievement, however, has not been found to improve with self-regulated instruction in the limited

number of studies addressing this parameter (Hannafin, 1981; Johnson and Croft, 1975; Keller, Goldman, and Sutterer, 1978; Morris, Suber, and Bijou, 1978), although evidence from the literature on mastery learning suggested that pacing may be a critical element in the acquisition of skills (Bloom, 1971). In total class instruction, the teacher provides a pace which all students follow in developing specific skills or acquiring information. Self-pacing provides the opportunity for each student to spend the specific amount of time necessary to acquire a stated skill.

In this study, critical thinking skills were taught through either teacher-paced or self-paced modes. Although the content of instruction in specific critical thinking skills was the same in the treatment groups, the methodology enabled students in the self-paced group to cover varying amounts of practice material, while those in the teacher-paced groups were to cover the same amount of material.

Are different teaching methodologies more appropriate to some students than others? A range of approaches are generally used in the teaching process. Recent research suggests that there is a wide variation in the preferred learning style of students (Keefe, 1979). Whether such a preference affects achievement was a research question addressed in this study. Learning style, as defined by Dunn, Dunn, and Price (1979), is the way in which individuals respond to emotional, sociological, environmental, and physical stimuli which affect a person's ability to absorb and retain information and skills. In this study a high, moderate, or low learning style preference for teacher structured

learning was used as one parameter in order to determine whether this preference affected achievement or attitudes under different instructional modes.

A review of the literature including the theoretical constructs, and the research related to thinking skills development, teaching strategies, and learning style are included in Chapter 2 of this study. The methodology, including the sample, research design, procedures, instrumentation, specific hypotheses and statistical analysis are located in Chapter 3 of the investigation. In Chapter 4 an analysis of the results for each hypothesis is outlined. The summary, conclusions, and recommendations for further research are contained in the final chapter.

Limitations of the Study

Ideally the development of critical thinking skills should occur throughout the educational process. Educational programs in kindergarten, for example, tend to focus on classification skills which formulate a basic structure for more complex functioning. At the twelfth grade level more theoretical and scientific issues can be addressed. Only one age group was selected for the purpose of this study, fifth grade students, age 11, where the maturational level as defined by Piaget (1954) makes the teaching of logical thinking feasible. The stages of cognitive growth prior to this level were not explored, thus limiting the study to a specific developmental stage, that of the student in fifth grade.

This study focused on and was limited to the specific critical thinking skills of inductive and deductive reasoning, and of the

classification and analysis of verbal and figural symbols. Other elements that may be related such as intuitive thinking and creative processes were beyond the scope of this investigation. It may be ideal for critical thinking skills to pervade the curriculum in many content areas. For the purposes of this study, however, the skills were taught in isolation.

CHAPTER 2

REVIEW OF THE LITERATURE

Summary of Rationale and Relationship to Problem

A belief that the educational process enhances the development of thinking skill is demonstrated by its inclusion in the listed goals of education. Sternberg (1981) suggests that intelligence itself consists of a set of developed thinking and learning skills. He further indicates that the function of education is to help students become aware of the skills and of ways to use them. Costa (1981; Note 2) proposes that teaching for intelligence is a primary goal of education, and as such requires time allocation, discussion, and practice in the instructional process. Feuerstein (1980) proposes a concept of cognitive modifiability which can affect the level of intellectual functioning in the individual, especially for those who may have deficits in specific functions. The works of Dewey (1933), Taba (1962), and Bruner (1975) suggest that teaching intelligent behavior is essential to the development of optimally functioning human beings. It was the intent of this study to investigate whether thinking skills can be developed by providing instructional experiences designed to promote higher level cognitive processes.

Theoretical Concepts

Three models describing cognitive aspects of intellectual function form a theoretical framework for examining critical thinking. Guilford's Structure of the Intellect, Piaget's Stages of Cognitive Development, and Bloom's Taxonomy of the Cognitive Domain are briefly reviewed as follows:

Guilford's Structure of the Intellect Guilford (1966) in his "Structure of the Intellect" constructs a three-dimensional model of human intellectual functioning consisting of products, operations, and contents. Standard intelligence tests generally sample behaviors from only certain of the dimensions, particularly those of convergent production in the symbolic and semantic modes. The educational system also is designed to reinforce those who do well in these modes and tends to focus on these dimensions. The model, however, describes intelligence as a multiplicity of factors which can be identified and developed. In developing critical thinking, the operations, contents, and products of the Guilford model require consideration in preparing appropriate learning experiences (see Figure 2.1).

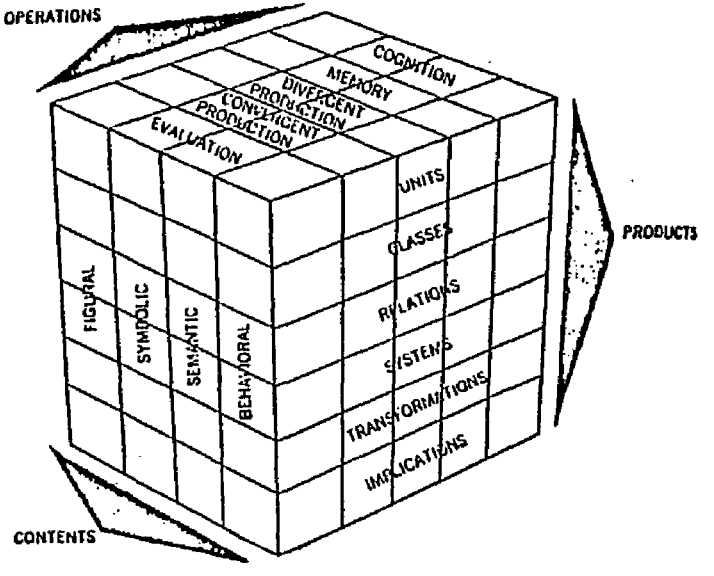
Piaget's Stages of Cognitive Development The processes by which intellectual function or cognitive structure is acquired were studied by Piaget (Flavell, 1963; Piaget, 1970, 1973; Varma and Williams, 1976) through a series of longitudinal studies. His work, focusing on the development of logical thinking processes and symbolic structures, led to a theoretical framework of chronological stages in the thought process. These stages, according to the Piagetian construct, develop through maturation as the organism interacts with the environment. Although the chronological ages at which each stage occurs may vary, the sequence of stages is invariant. The stages are outlined as follows:

Sensorimotor Stage (Approximately 0 to 2 years of age)

This stage is preverbal. The child develops the concept of permanence of an object, becomes able to distinguish himself

TEACHING/LEARNING MODEL

Guilford's
Structure of the Intellect



Purpose: This structure presents the various components and classification of the intellectual factors. It indicates that an ability is a combination of an operation or process, a content, and a product.

Implications	Applications
Analysis of teaching strategies	Individualizing instruction, classroom discussions, questioning, in-service training
Evaluation of student performance abilities	Developing strengths, correcting weakness, parent-teacher discussions, student placement, setting goals and objectives
Assigning of appropriate learning activities to the gifted	Emphasizing divergent and evaluative thinking operations
Applying to learning experiences	Differentiating the curriculum, developing curriculum

Products

Units--Items of information having "thing" character
Classes--Items of information grouped for their common properties
Relations--Connections between units of information
Systems--Organized or structured aggregates of items of information
Transformations--Changes of various kinds in existing or known information or in its use
Implications--Extrapolations of information, in the form of expectancies, predictions, known or suspected antecedents, concommitants, or consequences

Operations:

Cognition--Recognizing problems, needs
Acquiring knowledge
Memory--Recalling facts
Convergent Production--Finding an anticipated and/or correct answer
Divergent Production--Producing an original, unexpected response
Evaluation--Reaching decisions; making judgements

Contents:

Figure content--Information in concrete forms, as perceived or as recalled in the form of images
Symbolic content--Information in form of signs, such as letters, numbers, musical notations, and other "code" elements
Semantic content--Information in the form of meanings to which words commonly become attached
Behavioral content--Information, essentially nonverbal, involved in human interactions (22).

Figure 2.1 Guilford's Structure of the Intellect Model (Kaplan, 1974)

from other objects and persons, and reacts reflexively through sensory input. Some symbolization begins to formulate toward the end of this period.

Pre-operational Stage (Approximately 2 to 7 years of age)

Symbolic thought develops with the advent of language. The child is perceptually oriented and egocentric. He uses intuitive, not logical thinking and sees only one property or variable at a time. Thinking is transductive rather than inductive or deductive. In transductive thinking the individual proceeds from particular to particular rather than from the general to the particular (deductive) or from the particular to the general (inductive).

Concrete Operational Stage (Approximately 7 to 12 years of age)

Thinking is concrete rather than abstract but elementary logic operations are possible. The child is able to formulate groupings, classes and relationships. He is more objective but still has difficulty in isolating variables without concrete objects with which to work.

Formal Operational Stage (Approximately 12 to 15 years of age)

The child can use both inductive and deductive reasoning processes. He can isolate variables and reach conclusions. Logical thinking is superior to experimental ability and the individual can construct hypothetical situations and understand analogies.

It can be seen in examining the Piagetian stages that it is at the formal operational stage that the ability to think logically appears. This suggests a critical stage for providing experiences in logical thinking to maximize the development of such ability.

Bloom's Taxonomy From another perspective, Bloom (1956) presents a taxonomy of the cognitive domain which describes a hierarchy of learning where different skills are required at different levels of thinking. The hierarchy begins at the knowledge level and extends to the evaluation level as follows:

Knowledge: Mastery of the subject matter in terms of memory is emphasized.

Comprehension: Information is summarized, translated, explained, and paraphrased.

Application: Learned processes and information are used to solve new problems.

Analysis: The component parts of a total structure are identified in order to explain it.

Synthesis: Elements are combined to formulate a unique product or new perspective.

Evaluation: Judgment, viewpoint, and discrimination are used to produce an individual expression.

In the Bloom construct the higher levels (analysis, synthesis, and evaluation) are related to abstract concepts and critical thinking (Bloom, Hastings, and Madaus, 1971).

Although the levels described by Bloom are not directly related to maturational level, it would appear that more mature age groups should

spend a greater percentage of time using the higher cognitive levels than younger students who are still primarily engaged in acquiring information. These higher cognitive processes are considered to be congruent with critical thinking.

Each of the above theorists suggests that intellectual functioning is multi-dimensional, with levels of thinking being cumulative, interrelated, and the result of interaction between the human organism and the environment. The work of Piaget suggests a chronological or maturational stage when logical thinking can be developed; Bloom outlines levels of cognition which increase in complexity; and Guilford provides insight into how information is processed, stored, and used. This study on developing critical thinking ability was designed to be used with students at the beginning of the formal operational stage defined by Piaget; to develop the higher levels of thinking outlined by Bloom (analysis, synthesis, and evaluation); and to use the Guilford construct to provide for experiences that tap a variety of contents, products, and operations.

Relevant Research

The areas of research relevant to this study were (1) studies on the development of critical thinking, (2) instructional methodology, and (3) the learning style of the student population. Each of these areas is reviewed as follows:

Development of Critical Thinking Skills Days, Wheatley, and Kulm (1979) found better mathematical problem-solving ability in students who had reached Piaget's formal-operational level of development as opposed to those at the concrete-operational level. Although the work of Piaget

indicates that such reasoning ability emerges around the age of 11 or 12, studies that show a high percentage of students in the secondary school population do not have this capability (Mason, 1974; Wells, 1972). It seems reasonable to assume that this lack of logical thinking skill may be due to neglect in providing students with experiences that promote it. In critical thinking the individual must comprehend the essential elements of an argument, evaluate the available evidence, analyze assumptions, and draw conclusions (Hudgins, 1977). Training in the ability to reason appears essential to the development of the logical thinking ability which promotes higher cognitive functioning.

Although the theoretical evidence is substantial, research studies of actual instruction in thinking skills are limited. Two general approaches have, however, been used in the attempt to promote higher cognitive functioning, the use of higher level questioning and direct instruction in logical thinking. Winnie (1979) in a review of experiments relating the use of higher level questioning to academic achievement found no effect present in most studies, particularly in those designed specifically to train higher level thinking. In examining the effect of high cognitive level questions versus low level cognitive questions with classes of elementary students, no difference in student achievement was found (Clark, Gage, Marx, Peterson, Staybrook, and Winnie, 1979; Gail, Ward, Berliner, Cohen, Winnie, Elashoff, and Stanton, 1978).

The direct instruction in critical thinking appears to have had more positive results on the student's ability to reason than the use of higher level questioning. Morgan and Carrington (1944) instructed

elementary students in reasoning skills through the use of graphical representation. Classes engaged in instruction showed improvement in reasoning, especially at the third and fourth grade levels which appeared to be critical ones for using graphic illustration. Students in fifth and sixth grades in this study were more able to do logical thinking abstractly without the dependence on graphical representation.

Hyram (1957) after training seventh and eighth grade students for four months through units on the nature of thinking, definition, and inference, found significant gains in logical reasoning by the experimental group. Through an approach which used social studies content to improve thinking in elementary school children, Taba (1960), in a large field study failed to demonstrate a greater ability of students in the experimental groups to draw inferences and to apply principles than in students in control groups. However, the large number of variables and subjects in the study did, as observed by the author, contribute to contaminated results.

In a study by Wright (Note 3), instruction in critical thinking using inductive and deductive methods resulted in significant improvement by 369 sixth grade students in reasoning ability. Lipman (1973) in the teaching of the philosophy of logic to fifth graders, demonstrated more advanced logical thinking and mental maturity in the experimental group.

The use of direct teaching methodology for developing critical thinking is suggested by Soar (1968, 1972). In assessing the achievement of third through sixth graders in 55 classrooms who received direct versus indirect instruction, no clear evidence in favor of either existed.

However, more abstract and complex tasks were found more optimally attained through direct instruction, while simple learning tasks were accomplished by indirect methodologies. Soar postulates that the nature of the task determines the optimum teaching strategy, suggesting direct instruction being of particular value with more complex skills.

Glenn and Ellis (1982) examined the effect of direct versus indirect methods of teaching problem solving to elementary students classified as stimulus-free or stimulus-bound in thinking style. The direct method of instruction resulted in students who used a more systematic and effective method of problem solving regardless of thinking style. Ward (1979, 1982, Note 2) found that direct instruction in higher level thinking skills of analysis, synthesis, and evaluation resulted in an elevation of higher cognitive processes in elementary gifted students than in those not so instructed. This finding suggests that even students in the highest ability range do not automatically develop critical thinking skills.

The studies on direct instruction of critical thinking indicate the necessity of training logical reasoning in order to develop higher cognitive function. Additionally, the paucity of work in this area demonstrates a need for additional research on the effect of specific instruction in the development of higher cognitive functions. The type of instruction used in this study, therefore, was direct instruction of critical thinking skills focusing on verbal and figural analogies, and deductive and inductive reasoning.

Instructional Methodology Learning which is self-directed or intrinsically motivated is often cited as an educational goal. Variation in pacing, choice of learning activities, individual goal setting, and self-evaluation are instructional modifications used to provide more self-direction. An increased time-on-task was found in classrooms where students set their own goals and monitor them (Sagotsky, Patterson, and Lepper, 1978). Students who had opportunities to regulate their own instruction reported greater responsibility for their own achievement than those whose instruction was externally managed (Arlin and Whitley, 1978). Improved attitudes are reported in studies where students have opportunities for self-goal setting and self-pacing (Hannafin, 1981; Morris, Suber, and Bijou, 1978). Achievement, as measured by test performance, has not been found to improve as the result of self-regulated instruction (Johnson and Croft, 1975; Keller, Goldman, and Sutterer, 1978; Morris, Suber, and Bijou, 1978). Hannafin (1981) found that students who set their own goals set fewer but attained more than in classes in which teachers set goals for the students. A mathematics computational test, however, did not show a significant difference between groups in achievement.

Studies using the mastery learning approach outlined by Bloom (1971) and implemented by several investigators (Block, 1979; Block and Anderson, 1975; Hyman and Cohen, 1979) indicate that student achievement was improved when pacing was designed to meet individual needs. Students given additional time and instruction in mastering specified objectives resulted in larger numbers of students achieving desired goals.

Pacing, then, appeared to be one factor affecting achievement and attitude and was selected for use in this study. Students in self-paced groups covered varying amounts of practice material at different levels of difficulty. Students in teacher-paced groups worked with teacher specified practice materials during each session.

Learning Style The type of instruction as related to the learning style of the student and the resultant achievement is currently the subject of research investigation. Dunn and Dunn (1978) portray the parameters of learning style in the following model:

STIMULI	ELEMENTS					
ENVIRONMENTAL	SOUND	LIGHT	TEMPERATURE	DESIGN		
EMOTIONAL	MOTIVATION	PERSISTENCE	RESPONSIBILITY	STRUCTURE		
SOCIOLOGICAL	COLLEAGUES	SELF	PAIR	TEAM	AUTHORITY	VARIED
PHYSICAL	PERCEPTUAL	INTAKE	TIME	MOBILITY		

Dunn, Dunn, and Price (1979) also suggest a psychological component developed through the discipline of psychology, usually referred to as cognitive style although it is sometimes used interchangeably in the literature with the term learning style. Cognitive style as defined by Kogan (1971) is the individual variation in the modes of perceiving, remembering, and thinking, or as distinctive ways of apprehending, storing, transforming, and utilizing information. Some of the major cognitive dimensions which have received attention are:

> Field Dependence vs. Field Dependence: an analytical, in contrast to a global, way of perceiving which entails a tendency to distinguish items as discrete from their backgrounds, and an ability to overcome the influence of an

embedding context (Witkin, 1962; 1967).

Reflectiveness vs. Impulsivity: the speed with which hypotheses are selected and information processed. Reflective subjects tend to ponder the possibilities before selection and are usually more accurate than impulsive subjects (Kagan, 1964).

Risk Taking vs. Cautiousness: risk taking generally implies that low probability - high payoff alternatives are preferred while cautiousness implies the opposite order or preference (Kogan and Wallack, 1964).

Internal vs. External Locus of Control: this dimension is a combination of cognitive and social dimensions which refers to the individual's perception of how behavior is controlled. Internal locus of control individuals feel that they control their own behavior while those who are classified as having an external locus perceive others as controlling their behavior (Norwicki and Strickland, 1973; Rotter, 1966).

Students with higher measured ability have been found to be more field independent (Witkin, et al., 1962) and to have an internal rather than external locus of control (Fincham and Barling, 1978). Inductive reasoning tasks (related to some subtests of most intelligence tests) were more accurately and quickly completed by reflective rather than impulsive first grade children (Kagan, Pearson, and Welch, 1966). Stewart (1981) found a learning style preference for independent study and discussion in gifted students versus a preference for lecture and projects in non-gifted students. The learning style preference among

these students was affected by grade, sex, locus of control, and favorite subjects but not by achievement. Less preference for teacher structure, auditory learning, and informal classroom designs were found among gifted students by Dunn and Price (1980).

The relationship between learning style or cognitive style and achievement has been explored in several studies. High achieving students were found to be more field independent (Sauerman and Michael, 1980). Greater reading achievement was found in students who were persistent, responsible, and self-motivated (Price, Dunn, and Sanders, 1981). Students with an internal locus of control and classified as field independent received higher grades in tenth grade English (Anderson and Bruce, 1979).

The above studies suggest the variability present in the learning styles of students. Teaching methodologies generally utilize a variety of strategies in an effort to cover the varied learning styles of students in a class (Turner, 1979). It has been suggested that the matching of learning style to method of instruction may improve student performance (Sheriff and Williams, Note 4; Dunn and Dunn, 1979).

In a study by Horak (Note 5), students who were classified as field dependent learned more from an inductive method of teaching mathematics while those who were field independent learned equally well either through inductive or deductive modes. Low achieving students preferred questioning strategies of inquiry while high achieving students preferred memory techniques in a study by Heller (Note 6). These studies suggest a relationship between learning or cognitive style, instructional

methodology or teaching style, and achievement, a relationship which requires further investigation before appropriate applications to educational practices can be made.

Summary of Research and Relationship to Problem

The three theoretical models (Guilford, 1966; Piaget, 1970, 1973; and Bloom, 1956) reviewed provided the framework for developing higher cognitive processes through appropriate learning experiences at the optimum stage of development. In this study, the higher cognitive processes to be developed were those defined by Bloom as analysis, synthesis, and evaluation. The teaching of critical thinking skills (deductive and inductive reasoning, and verbal and figural analogies) to enhance higher cognitive function were derived from Guilford's work. The formal operational stage of cognitive development outlined by Piaget suggests a critical time for developing logical reasoning processes, and thus guided the selection of the specific population for this study.

Of the eleven studies reviewed on the development of critical thinking, it appeared that indirect methodologies were less effective (Clark, et al., 1979; Gail, et al., 1978; Winnie, 1979), while direct instruction in logical reasoning increased student performance in higher level cognition (Glenn and Ellis, 1982; Hyram, 1957; Lipman, 1973; Morgan and Carrington, 1944; Soar, 1972; Taba, 1960; Ward, 1979; Wright, Note 3). The lack of research studies on the development of critical thinking suggested that efforts needed to be directed toward such an objective in order to validate the theoretical postulates. For this reason, the primary objective of this study was to determine the effect of direct

instruction of critical thinking skills on the development of higher cognitive function.

Whether learning is more optimal when the student regulates the pacing or when the teacher specifies the amount of material to be covered was reviewed in eleven studies. Self-pacing in four of these studies (Arlin and Whitley, 1978; Hannafin, 1981; Morris, et al., 1978; Sagotsky, et al., 1978) demonstrated improved attitudes toward instruction; three studies demonstrated improved achievement with individual pacing (Block, 1979; Block and Anderson, 1975; Hyman and Cohen, 1979), and four studies showed no differences in achievement between self-paced and teacher-paced groups (Hannafin, 1981; Johnson and Croft, 1975; Keller, et al., 1978; Morris, et al., 1978). None of these studies examined the preferred learning styles of the subjects which may in part determine the optimal conditions for maximum student performance.

The eleven studies reviewed on learning styles demonstrated a significant variability in the learning or cognitive styles of students (Dunn and Dunn, 1978; Dunn, Dunn, and Price, 1979; Dunn and Price, 1980; Fincham and Barling, 1978; Kagan, 1964; Kagan, et al., 1966; Kogan and Wallack, 1964; Norwicki and Strickland, 1973; Rotter, 1966; Stewart, 1981; Witkin, 1962, 1967). The eight studies cited which explored the relationship between learning style and instructional methodology indicated that this relationship may affect student achievement (Anderson and Bruce, 1979; Dunn and Dunn, 1979; Heller (Note 6); Horak (Note 5); Price, et al., 1981; Sheriff and Williams (Note 4); Sauerman and Michael, 1980; Turner, 1979). Research on learning style, however, is relatively

recent and is limited to a small number of studies. The effect of these parameters has not been addressed in the development of higher cognitive function, development which theoretically could be significantly influenced by a congruence between learning or cognitive style and instructional methodology. It was a further purpose of this study, then, to examine whether a match between learning style and instructional method resulted in improved student performance on higher level cognitive tasks.

CHAPTER 3

METHODOLOGY

The purpose of this study was to determine the effect of direct instruction of critical thinking skills on the achievement of higher cognitive tasks by elementary students and to examine whether a match between learning style preference and instructional method resulted in improved performance. A further purpose was to determine whether the type of instruction and the learning style preference resulted in different student reactions or attitudes toward the critical thinking skills program.

The methodology to accomplish these purposes has been outlined in this chapter as follows: (a) Sample; (b) Research Design; (c) Procedures; (d) Instrumentation; (e) Statistical Hypothesis; (f) Analysis; and (g) Summary.

Sample

The sample consisted of 135 second-semester fifth grade elementary students in two elementary schools located in a rural-suburban school district with a total school population of 8,700. The school district reflected a predominately middle class socioeconomic population, was in the mid-Atlantic coastal region, and had a racial composition of approximately 82% white and 18% black. Students scored above average in achievement on national standardized achievement tests (approximately the 65th percentile on the composite score).

The schools were selected for the study on the basis of a comparable population in terms of socioeconomic status (middle income), ethnic background (approximately 85% white, 15% black), achievement (approximately in the 60th percentile on standardized achievement tests), and size

(approximately 550 students in each school). Each school had three fifth grade classes taught by teachers who had comparable teaching experience (8 to 15 years) and had prior experience in the school division (3 to 15 years).

Design

The research design was experimental with students randomly assigned to three groups in each school: treatment one, treatment two, and control. The random assignment was stratified according to a high, moderate, or low preference for teacher-structured learning, resulting in a factorial design (3 x 2 x 3) as shown in Table 3.1.

Post-test measurements of achievement of higher level thinking processes were conducted in all three groups and served as the dependent variables. Post-test attitude measures were administered to the treatment Groups, A_1 and A_2, only, since the control group, A_3, was not instructed in critical thinking skills.

Procedures

Random Assignment Procedure Fifth grade students in the two schools (72 and 63 respectively) were randomly assigned to the two treatment groups and the control group in each school using a random block assignment procedure. The administration and scoring of the Learning Style Inventory (Appendix B) classified students as having a high, moderate, or low preference for teacher structure. Using a random number table, equal numbers of students from each preference group were assigned to the teacher-paced, self-paced, and control groups as shown in Table 3.1. The treatment groups in each school were of equal size and no mortality occurred during the time the study was conducted.

TABLE 3.1

NUMBER OF STUDENTS WITH DIFFERING LEARNING STYLE PREFERENCES IN THREE TREATMENT GROUPS

		Treatment			
		A_1 Teacher-Paced	A_2 Self-Paced	A_3 Control	Total
School B_1	Learning Style Preference C_1	5	5	5	15
	Learning Style Preference C_2	12	12	12	36
	Learning Style Preference C_3	4	4	4	12
	Total	21	21	21	63
School B_2	Learning Style Preference C_1	5	5	5	15
	Learning Style Preference C_2	14	14	14	42
	Learning Style Preference C_3	5	5	5	15
	Total	24	24	24	72
Total Group (Both Schools)	Learning Style Preference C_1	10	10	10	30
	Learning Style Preference C_2	26	26	26	78
	Learning Style Preference C_3	9	9	9	27

N = 135

Treatment A_1 was teacher-paced instruction of critical thinking skills.

Treatment A_2 was self-paced instruction of critical thinking skills.

Treatment A_3 was a control group with no instruction in critical thinking skills.

TABLE 3.1 (continued)

Learning Style Preference C_1 was a low preference for teacher-structured learning.

Learning Style Preference C_2 was a moderate preference for teacher-structured learning.

Learning Style Preference C_3 was a high preference for teacher-structured learning.

Teacher Training Procedure The three fifth grade teachers at each school were assigned randomly to the two experimental groups and to the control group. All six teachers received approximately eight hours of training prior to the commencement of the study. The four training sessions were:

Session 1. Theory and research base for critical thinking skills.
Nature and reason for the study.

Session 2. The instructional materials.
Specific teaching methodologies.

Session 3. Demonstration of teaching lessons.
Practice in each type of lesson and problem.

Session 4. Monitoring processes.
Record keeping procedures.
Testing procedures.
Time schedules.

Weekly meetings or conferences with teachers conducting the experimental classes were held to discuss any difficulties, problems, and/or the on-going progress of the work.

Instructional Procedures Objectives, instructional strategies, daily lesson plans, charts, overhead transparencies, student worksheets, and answer keys were developed for each unit of instruction and were housed in a curriculum notebook. For easy access student copies of worksheets were filed in folders placed in portable containers. All instructional materials were carefully scripted so that teachers could deliver lessons as similar in nature as possible.

The materials used for instruction were verbal analogies and inductive thinking skill problems written for the study; adaptations of deductive and inductive thinking problems and figural analogy problems designed by Harnadek (1976, 1982), Gallagher, J.J. (1975), Post and Eads (1982), and Ryan (1971); and a problem solving process developed by Parnes, Nodler, and Biondi (1976).

Students in the treatment groups engaged in learning critical thinking skills for seven weeks, 25 minutes per day, five days per week, or approximately 15 hours of instruction as follows:

One Week - Introduction to Thinking Skills

Two Weeks - Verbal Analogies

One Week - Figural Analogies

One and One-Half Weeks - Deductive Thinking Skills

One and One-Half Weeks - Inductive Thinking Skills

The selection of the content was based on skills most often defined in critical thinking: classification of and relationships between verbal and non-verbal symbols and both deductive and inductive thinking processes. The content for the instructional program was the same in both treatment groups.

The teaching-learning process used for each unit of instruction included the following steps:

1) Statement of the objective and the rationale.

2) Direct teaching of the concept.

3) Guided practice.

4) Independent practice

5) Student designed problems.

6) Evaluation and summary.

Discussion and the exchange of ideas were encouraged throughout the instructional process.

Treatment Group A_1 was a teacher-paced class where the problem was introduced, identified, discussed, practiced, and corrected as a total class. In this group teacher direction was provided to each student in essentially the same quantity and each student completed a similar amount of material. Students kept a log of work completed and rated the difficulty of each program section (Introduction, Verbal Analogies, Figural Analogies, Deductive Skills, and Inductive Skills). A copy of the log used can be found in Appendix A.

Treatment Group A_2 was a self-paced class where, after the original introduction of the problem and instruction on processes, each student proceeded through the material at his own pace. Material congruent with the objective was available at increasing levels of complexity and/or difficulty, and was designed so that students could cover varying amounts of material according to their own progress. Students who needed additional help received individual assistance from the teacher. The problems were self-corrected by students through the use of available answer keys. Students kept the same log as in Treatment Group A_1. Daily work in both treatment groups was collected for monitoring and analysis.

Treatment Group A_3, the control group, did not receive instruction in critical thinking skills. During the time period assigned for critical thinking skills instruction these groups worked on social studies, poetry, writing, and drama projects developed by the teachers.

The project was initiated in school B_1 first, followed by School B_2 six weeks later in order to accommodate the teacher training schedule, use of materials, and necessary monitoring time. The instructional period for critical thinking in school B_1 was the first part of the school day. In the second school, because of its schedule, instruction occurred following lunch. The eighth week of the work in each school was used for testing procedures.

Classroom observations and audio cassette tapes of lessons were made periodically to insure that teachers were following the specific procedures in the curriculum guide to implement the instructional program.

Assessment Procedures The Otis-Lennon Mental Ability Test was administered to each student prior to the study for the purpose of assessing the ability or intelligence quotient. The scores obtained were to be used as a covariant in the analysis of achievement of higher level thinking skills if significant differences occurred between treatment groups. They were also used as a baseline for gains in ability scores that might occur as a result of the instructional procedures.

The Learning Style Preference Inventory was administered to all students prior to the random assignment to treatment groups. The Norwicki Internal-External Locus of Control Instrument was also administered to all students prior to assignment.

Monitoring forms were kept by students and teachers during the instructional period for each program component (Appendix A).

Following the seven-week instructional program, the Ross Test of Higher Cognitive Process was administered to all students to assess the achievement of critical thinking skills. Also the Otis-Lennon Mental Ability Test was administered to all students following the instructional period to determine whether differences in ability scores existed due to the instructional program.

An attitude inventory was administered to students in the two treatment groups to assess student reaction to the instructional program in thinking skills (Appendix A).

All test administration was conducted under standardized conditions following procedures outlined in the testing manuals and as detailed in instructions for teachers. The scoring of tests and recording of data were verified by a teacher and a computer consultant who were not involved in the experimental component of the study.

Instrumentation

Available instrumentation to assess the development of critical thinking skills or higher cognitive processes has been limited. The choices were the use of a group intelligence or ability measure and more recently developed tests designed to measure higher levels of cognition as defined by Bloom (1956). One of each was selected for use in this study, the selection being based on the instrument with the greatest reliability and validity and which matched, in part, the instructional program.

The Otis-Lennon Mental Ability Test (Otis and Lennon, 1968) was used to measure intelligence. This group administered test has a reliability of .94 to .96 and concurrent validity with other intelligence scales.

Buros (1972), Seventh Mental Measurement Yearbook, indicates the test to be valid and reliable as a group intelligence measure. As indicated by the test developers, this instrument was constructed with an emphasis on measuring the students' facility in reasoning and in dealing abstractly with verbal, symbolic, and figural items. Performance on these tasks, reflects, to some extent, experience the student has had in working with abstract relationships among words, numbers, and other symbols. Raw scores attained by students on this test were converted to Deviation I.Q. scores, a normalized standard score of 100 with a standard deviation of 16 points, through the technical conversion tables available.

Specific items on this test included verbal analogies and meanings, figural analogies and relationships, and numerical relationships and problem solving. Because of the relatively large numbers of analogy items on this test, it more closely matches the instructional program in critical thinking used in this study than other available measures. It did not, however, divide skills into subtests, but used a variety of items for a total ability score. The scores obtained on this test were used as a measure of the achievement of higher level thinking skills.

The Ross Test of Higher Cognitive Processes (Ross and Ross, 1976) was used as another measure of the dependent variable, higher level thinking skills. This instrument was designed to measure the levels of analysis, synthesis, and evaluation of the Bloom taxonomy in elementary students (grades 4 to 6). The subsections of the test are: Analogies, Missing Premises, and Analysis of Relevant and Irrelevant Information which measure the analysis level; Deductive Reasoning, and Questioning

Strategies which measure the evaluation level; and Abstract Relationships, Sequential Synthesis, and Analysis of Attributes which measure synthesis. The 105 item test has been normed on both gifted and non-gifted populations and has a split-half reliability of .92 and a test-retest reliability of .94, both significant at beyond the .001 level of confidence. Construct validity of chronological age and total scores was found to be .674. Raw scores were used for measurement of achievement on this test. The mean scores and standard deviations were calculated for this study, and a comparison of these results with those provided in the technical manual of the Ross Test can be found in the results.

Callahan and Corvo (1980) did a validation study of the Ross Test which (1) provided evidence for the structural validity of this measure through a factor analysis of each subtest, (2) supported the view that the Ross Test is neither an intelligence nor an achievement test through correlational data collected, and (3) indicated an appropriate use of the instrument to be evaluation of programs designed to teach higher level thinking skills.

The subsection of the test most closely related to the instructional program was the verbal analogy section. The deductive reasoning items were similar in process to the instructional problems, but not in format. The relevant and irrelevant information items were similar in process but not format to a section of the inductive reasoning component of instruction. The entire test battery was used in order to determine whether transfer occurred from one type of thinking skill to another and whether the total score would be affected by treatment or learning style preference.

An open-ended problem designed for the study was used to assess the inductive thinking process achieved. However, quantification of responses proved to be impossible.

Several learning style inventories were examined for possible use in this study. The Learning Style Inventory (LSI) developed by Dunn, Dunn, and Price (1978) and the Renzuli Learning Style Inventory (1976) assess multiple components of learning style and thus had an insufficient number of items addressing the parameter of self-pacing or structure versus teacher-pacing or structure preferences needed for the study. The Group Embedded Figures Test (Ottman, Raskin, and Witkin, 1971) which measures field dependence versus field independence was not designed nor normed for the age group used; a complex, individual test would have been necessary to assess this parameter in children which was not feasible in this study.

A Learning Style Inventory was therefore designed to measure a preference for self-pacing and structure versus a preference for teacher-pacing of instructional work. A copy of the instrument and the scoring procedure can be found in Appendix B. A test-retest reliability coefficient of 0.85 was obtained for this instrument. Internal consistency was measured by a correlation of the first eight items matched with the second eight items on the sixteen item inventory (Appendix B).

The Norwicki-Strickland Scale (1973) for measuring locus of control was administered to determine the relationship between locus of control and preference for teacher-pacing. The correlation was low (0.22) and the range of scores limited; therefore this instrument was not used in the stratification process for random assignment purposes.

A rating scale was designed to measure student response to the instructional program on critical thinking skills. Student ratings on the items were used to assess the attitude of the treatment groups toward learning critical thinking skills. A copy of this instrument and the scoring procedure can be found in Appendix A.

Statistical Hypothesis

The hypotheses of this study were:

H_0^1 There was no significant difference in the achievement of higher level thinking in fifth grade students among the teacher-paced instructional groups, the self-paced instructional groups, and the control groups.

H_0^2 There was no significant difference in achievement of higher level thinking between groups of students differing on levels of preference for teacher-structured learning.

H_0^3 There was no significant interaction between treatment and preference on student achievement of higher level thinking.

H_0^4 There was no significant difference in the attitudes of students toward instruction of critical thinking skills between the teacher-paced group and the self-paced group.

H_0^5 There was no significant difference in the attitudes of groups of students differing on levels of preference for teacher structured learning toward the instructional program in critical thinking skills.

H_0^6 There was no significant interaction between treatment and preference in students' attitudes toward the instruction of critical thinking skills.

Analysis

The means and standard deviations of achievement scores of students in all eighteen cells of the experimental design were computed (Figure 2). The means and standard deviations of scores on attitudinal measures were computed in the twelve cells representing students in experimental groups, A_1 and A_2.

A three-way analysis of variance (3 x 3 x 2) (ANOVA) was used to determine whether significant differences ($p < .05$) in the achievement of higher level thinking skills existed as the result of the main effects of Treatment (A), Schools (B), and Learning Style (C), as well to determine any interaction effects, AB, AC, BC, and ABC.

An analysis of covariance (ANOVA) was used to determine whether significant differences ($p < .05$) in ability scores existed due to Treatment (A), Schools (B), and Learning Style Preference (C), as well as any interaction effects, AB, AC, BC, and ABC. The post-test ability scores were covaried by the pretest ability score.

A three-way analysis of variance (2 x 3 x 2) was used to determine whether significant differences ($p < .05$) in student attitude toward learning critical thinking skills existed because of the main effects of Treatment (A), Schools (B), and Learning Style (C), as well as any interaction effects, AB, AC, BC, and ABC.

The null hypotheses were rejected if significant differences ($p < .05$) were found between groups.

The data and statistical analyses were verified by the computer consultant at the College of William and Mary.

FIGURE 3.1

EXPERIMENTAL DESIGN FOR TREATMENT AND LEARNING STYLE GROUPS

		Treatment		
		A_1 Teacher-Paced	A_2 Self-Paced	A_3 Control
School B_1	Learning Style Preference C_1			
	Learning Style Preference C_2			
	Learning Style Preference C_3			
School B_2	Learning Style Preference C_1			
	Learning Style Preference C_2			
	Learning Style Preference C_3			

Summary

Fifth grade students (n = 135) in two elementary schools were randomly assigned to three groups, two treatment and one control, using a random block design based on a high, moderate, or low preference of students for teacher-structured learning.

Trained teachers, randomly assigned by drawing the treatment group number from a hat, instructed students in the treatment groups in the development of critical thinking skills. A seven week program of instruction in verbal analogies, figural analogies, deductive thinking, and inductive thinking was conducted using a curriculum guide developed

for the study containing objectives, instructional strategies, scripted lesson plans, and instructional materials. Instruction in one treatment group was teacher-paced with the material presented, practiced, and corrected as a total class. Instruction in the second treatment group was self-paced where, after initial presentation, students proceeded at their own pace and corrected their own work. The control group did not receive instruction using critical thinking skills materials.

Following the seven week, daily instructional program of 25 minutes per day, the achievement of higher level thinking skills was tested by the administration of the Otis-Lennon Mental Ability Test and the Ross Test of Higher Cognitive Processes. An attitude inventory to assess student response to the critical thinking skills program was also administered.

An analysis of variance was used on the achievement and attitude measures to determine whether significant differences ($p < .05$) existed as the result of the main effects of treatment, school, and learning style preference, as well as to determine any significant interaction effects between these parameters.

CHAPTER 4

ANALYSIS OF RESULTS

The purposes of this experimental study were to determine the effect of teacher-paced versus self-paced instruction of critical thinking skills on the achievement of higher cognitive skills in elementary students; to examine whether a student preference for high, moderate, or low teacher-structured learning resulted in differing achievement levels; and to assess whether the type of instruction and/or preferred learning styles had an effect on student attitude toward the instruction.

The following analyses by hypothesis were performed using all 135 subjects in the sample. The data obtained were subjected to an analysis of variance or an analysis of covariance. Monitoring data were also summarized to provide additional information.

Hypothesis $H_0{}^1$

This hypothesis states that there is no significant difference in the achievement of higher level thinking in fifth grade students among the teacher-paced instructional groups, the self-paced instructional groups, and the control groups.

The means and standard deviations of scores on the Ross Test of Higher Cognitive Processes, including each subtest, of students in each treatment group, each school, and in each learning style category were computed using the SPSS statistical package, BREAKDOWN. Pretest, post test, and difference intelligence scores (deviation I.Q.) on the Otis-Lennon Mental Ability Test were similarly computed for each cell. These results have been tabulated in Appendix C.

A three-way analysis of variance (3 x 2 x 3) using the SPSS program ANOVA was used to determine whether significant differences ($p < 0.05$) in the achievement of higher level thinking skills existed as the result of the main effects of Treatment (A), School (B), and Learning Style (C), as well as to determine any interaction effects, AB, AC, BC, and ABC.

The results of the analysis of variance on the ability (or intelligence) scores of the treatment groups showed no significant difference between groups in pretest scores (Table 4.1). In examining the differences between pretest and post-test ability scores, a significant difference ($p < 0.02$) was found in the groups that had received instruction (Table 4.2). The mean gains in the ability or deviation I.Q. scores were 4.19 and 3.96 in the teacher-paced groups, 6.85 and 4.29 in the self-paced groups, and 2.29 and 0.90 in the control groups (see Appendix C, Table C.2).

An analysis of covariance where the post-test ability score was covaried by the pretest ability score was performed. A significant difference ($p < 0.02$) was found in the treatment versus control groups (Table 4.3).

The results of the analysis on scores on the Ross Test of Higher Cognitive Processes and each of the subsections are contained in Tables 4.4 through 4.12. A significant difference in achievement ($p < 0.02$) between treatment groups was found in the verbal analogy section of the test (Table 4.5) where the groups which received instruction scored significantly higher. Mean scores for the teacher-paced instructional groups were 9.85 and 9.83, for the self-paced instructional groups 9.38 and 9.60, and for the control groups 7.90 and 8.70 (see Appendix C, Table C.4).

TABLE 4.1

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE PRETEST SCORES ON THE OTIS-LENNON MENTAL ABILITY TEST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	67.244	1	67.245	0.491	0.485
Treatment	76.459	2	38.230	0.279	0.757
Learning Style Preference (L.S. Pref.)	360.521	2	180.260	1.314	0.273
Interactions					
School x Treatment	63.179	2	31.590	.230	0.295
School x L.S. Pref.	186.013	2	93.007	.678	0.510
Treatment x L.S. Pref.	687.695	4	171.924	1.253	0.293
School x Treatment x L.S. Pref.	314.346	4	78.586	.523	0.683
School One					
Main Effects					
Treatment	93.556	2	46.778	0.441	0.646
L.S. Pref.	522.512	2	261.256	2.464	0.095
Interactions					
Treatment x L.S. Pref.	282.400	4	70.600	0.666	0.618
School Two					
Main Effects					
Treatment	46.083	2	23.042	0.141	0.869
L.S. Pref.	24.023	2	12.011	0.073	0.929
Interactions					
Treatment x L.S. Pref.	719.640	4	179.910	1.097	0.366

TABLE 4.2

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE
I.Q. DIFFERENCE, PRETEST TO POST TEST, ON THE OTIS-LENNON MENTAL ABILITY TEST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	7.430	1	7.430	0.177	0.675
Treatment	340.044	2	170.022	4.047	0.020*
Learning Style Preference (L.S. Pref.)	93.966	2	46.983	1.118	0.330
Interactions					
School x Treatment	88.432	2	44.216	1.052	0.352
School x L.S. Pref.	40.427	2	20.214	0.481	0.619
Treatment x L.S. Pref.	295.149	4	73.787	1.756	0.142
School x Treatment x L.S. Pref.	55.388	4	13.847	.330	0.858

*Significant at $p < 0.05$.

TABLE 4.3

HYPOTHESES 1, 2, 3 - ANALYSIS OF COVARIANCE OF THE POST-I.Q. SCORES ON THE OTIS-LENNON MENTAL MATURITY TEST: COVARIATE = PRE-I.Q. SCORES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Main Effects	439.148	5	87.830	2.073	0.074
School	7.418	1	7.418	0.175	0.676
Treatment	339.570	2	169.785	4.008	0.021*
Learning Style Preference (L.S. Pref.)	91.726	2	45.863	1.083	0.342
Interactions					
School x Treatment	91.443	2	45.721	1.079	0.343
School x L.S. Pref.	41.138	2	20.569	0.486	0.617
Treatment x L.S. Pref.	291.486	4	72.872	1.720	0.150
School x Treatment x L.S. Pref.	56.182	4	14.046	0.332	0.856

*Significant at $p < 0.05$.

TABLE 4.4

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE TOTAL ROSS TEST OF HIGHER COGNITIVE PROCESS SCORES

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	9.786	1	9.786	0.085	0.771
Treatment	520.770	2	260.385	2.256	0.109
Learning Style Preference (L.S. Pref.)	499.309	2	249.654	2.163	0.120
Interactions					
School x Treatment	406.976	2	203.488	1.763	0.176
School x L.S. Pref.	887.303	2	443.652	3.844	0.024*
Treatment x L.S. Pref.	437.942	4	109.486	0.949	0.439
School x Treatment x L.S. Pref.	556.796	4	139.199	1.206	0.312
School One					
Main Effects					
Treatment	442.413	2	221.206	1.663	0.199
L.S. Pref.	1100.079	2	550.039	4.135	0.021*
Interactions					
Treatment x L.S. Pref.	323.776	4	80.944	0.609	0.658
School Two					
Main Effects					
Treatment	485.333	2	242.667	2.419	0.117
L.S. Pref.	286.533	2	143.267	1.428	0.097
Interactions					
Treatment x L.S. Pref.	670.961	4	167.740	1.672	0.168

*Significant at $p < 0.05$.

TABLE 4.5

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF
SCORES ON THE VERBAL ANALOGIES SUBSECTION OF THE ROSS TEST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	1.024	1	1.024	0.226	0.635
Treatment	38.326	2	19.163	4.233	0.017*
Learning Style Preference (L.S. Pref.)	11.528	2	5.764	1.273	0.284
Interactions					
School x Treatment	20.726	2	10.363	2.289	0.106
School x L.S. Pref.	65.751	2	32.876	7.262	0.001*
Treatment x L.S. Pref.	13.208	4	3.302	0.729	0.574
School x Treatment x L.S. Pref.	12.067	4	3.017	0.666	0.617
School One					
Main Effects					
Treatment	43.524	2	21.762	4.377	0.017*
L.S. Pref.	59.902	2	29.951	6.024	0.004*
Interactions					
Treatment x L.S. Pref.	8.965	4	2.241	0.451	0.771
School Two					
Main Effects					
Treatment	15.528	2	7.764	1.872	0.162
L.S. Pref.	17.378	2	8.689	2.095	0.132
Interactions					
Treatment x L.S. Pref.	16.310	4	4.078	0.983	0.423

*Significant at $p < 0.05$.

TABLE 4.6

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE SCORES ON THE DEDUCTIVE REASONING SUBSECTION OF THE ROSS TEST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	1.780	1	1.780	0.247	0.620
Treatment	23.881	2	11.941	1.656	0.195
Learning Style Preference (L.S. Pref.)	24.285	2	12.142	1.684	0.190
Interactions					
School x Treatment	11.535	2	5.768	0.800	0.452
School x L.S. Pref.	12.767	2	6.384	0.886	0.415
Treatment x L.S. Pref.	31.503	4	7.876	1.093	0.364
School x Treatment x L.S. Pref.	39.470	4	9.867	1.369	0.249
School One					
Main Effects					
Treatment	6.889	2	3.444	0.450	0.640
L.S. Pref.	20.607	2	10.304	1.345	0.269
Interactions					
Treatment x L.S. Pref.	23.967	4	5.992	0.782	0.542
School Two					
Main Effects					
Treatment	28.528	2	14.264	2.091	0.132
L.S. Pref.	16.444	2	8.222	1.205	0.306
Interactions					
Treatment x L.S. Pref.	47.006	4	11.751	1.723	0.156

TABLE 4.7

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE SCORES ON THE MISSING PREMISES SUBSECTION OF THE ROSS TEST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	0.127	1	0.127	0.054	0.816
Treatment	3.215	2	1.607	0.687	0.505
Learning Style Preference (L.S. Pref.)	8.480	2	4.240	1.813	0.168
Interactions					
School x Treatment	5.019	2	2.510	1.073	0.345
School x L.S. Pref.	*5.398*	*2*	*2.699*	*1.154*	*0.319*
Treatment x L.S. Pref.	15.783	4	3.946	1.687	0.158
School x Treatment x L.S. Pref.	3.383	4	0.846	0.362	0.836
School One					
Main Effects					
Treatment	4.984	2	2.492	0.925	0.403
L.S. Pref.	13.013	2	6.506	2.414	0.099
Interactions					
Treatment x L.S. Pref.	13.549	4	3.387	1.257	0.298
School Two					
Main Effects					
Treatment	3.250	2	1.625	0.799	0.454
L.S. Pref.	0.865	2	0.433	0.213	0.809
Interactions					
Treatment x L.S. Pref.	5.617	4	1.404	0.690	0.601

TABLE 4.8

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE SCORES ON THE ABSTRACT RELATIONSHIPS SUBSECTION OF THE ROSS TEST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	0.119	1	0.119	0.011	0.918
Treatment	6.711	2	3.356	0.301	0.740
Learning Style Preference (L.S. Pref.)	15.067	2	7.534	0.677	0.510
Interactions					
School x Treatment	82.467	2	41.234	3.705	0.028
School x L.S. Pref.	22.276	2	11.138	1.001	0.371
Treatment x L.S. Pref.	20.059	4	5.015	0.451	0.772
School x Treatment x L.S. Pref.	31.029	4	7.757	0.697	0.596
School One					
Main Effects					
Treatment	44.984	2	22.492	2.375	0.103
L.S. Pref.	27.670	2	13.835	1.461	0.241
Interactions					
Treatment x L.S. Pref.	15.883	4	3.971	0.419	0.794
School Two					
Main Effects					
Treatment					
L.S. Pref.	44.194	2	22.097	1.760	0.180
Interactions	9.673	2	4.837	0.385	0.682
Treatment x L.S. Pref.	35.205	4	8.801	0.701	0.594

TABLE 4.9

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE SCORES ON THE SEQUENTIAL SYNTHESIS SUBSECTION OF THE ROSS TEST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	1.630	1	1.630	0.199	0.657
Treatment	7.244	2	3.622	0.442	0.644
Learning Style Preference (L.S. Pref.)	12.524	2	6.262	0.764	0.468
Interactions					
School x Treatment	21.791	2	10.896	1.329	0.269
School x L.S. Pref.	21.915	2	10.957	1.336	0.267
Treatment x L.S. Pref.	12.442	4	3.111	0.379	0.823
School x Treatment x L.S. Pref.	25.964	4	6.491	0.792	0.533
School One					
Main Effects					
Treatment	7.841	2	3.921	0.545	0.583
L.S. Pref.	20.429	2	10.214	1.421	0.250
Interactions					
Treatment x L.S. Pref.	13.781	4	3.445	0.479	0.751
School Two					
Main Effects					
Treatment	21.194	2	10.597	1.169	0.317
L.S. Pref.	14.010	2	7.005	0.773	0.466
Interactions					
Treatment x L.S. Pref.	24.625	4	6.156	0.679	0.609

TABLE 4.10

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE
QUESTIONING STRATEGIES SUBSECTION OF THE ROSS TEST OF HIGHER COGNITIVE PROCESS

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	9.714	1	9.714	2.008	0.159
Treatment	26.548	2	13.274	2.744	0.068
Learning Style Preference (L.S. Pref.)	9.476	2	4.738	0.979	0.379
Interactions					
School x Treatment	1.154	2	0.577	0.119	0.888
School x L.S. Pref.	31.121	2	15.560	3.216	0.044*
Treatment x L.S. Pref.	9.366	4	2.341	0.484	0.747
School x Treatment x L.S. Pref.	17.208	4	4.302	0.889	0.473
School One					
Main Effects					
Treatment	10.508	2	5.254	0.870	0.425
L.S. Pref.	30.087	2	15.043	2.490	0.092
Interactions					
Treatment x L.S. Pref.	13.759	4	3.440	0.569	0.686
School Two					
Main Effects					
Treatment	17.194	2	8.597	2.259	0.113
L.S. Pref.	10.510	2	5.255	1.381	0.259
Interactions					
Treatment x L.S. Pref.	12.815	4	3.204	0.842	0.504

*Significant at $p < 0.05$.

TABLE 4.11

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE SCORES ON THE RELEVANT INFORMATION SUBSECTION OF THE ROSS TEST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	0.212	1	0.212	0.062	0.804
Treatment	8.104	2	4.052	1.183	0.310
Learning Style Preference (L.S. Pref.)	13.821	2	6.910	2.017	0.138
Interactions					
School x Treatment	3.182	2	1.591	0.464	0.630
School x L.S. Pref.	14.385	2	7.193	2.100	0.127
Treatment x L.S. Pref.	6.037	4	1.509	0.441	0.779
School x Treatment x L.S. Pref.	4.032	4	1.008	0.294	0.881
School One					
Main Effects					
Treatment	10.508	2	5.254	1.506	0.231
L.S. Pref.	24.448	2	12.224	3.505	0.037*
Interactions					
Treatment x L.S. Pref.	5.314	4	1.329	0.381	0.821
School Two					
Main Effects					
Treatment	0.778	2	0.389	0.115	0.891
L.S. Pref.	3.759	2	1.879	0.557	0.576
Interactions					
Treatment x L.S. Pref.	4.756	4	1.189	0.352	0.841

*Significant at $p < 0.05$.

TABLE 4.12

HYPOTHESES 1, 2, 3 - ANALYSIS OF VARIANCE OF THE SCORES ON ATTRIBUTES SUBSECTION OF ROSS TEST

Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
Both Schools					
Main Effects					
School	2.375	1	2.375	0.472	0.493
Treatment	16.904	2	8.452	1.680	0.191
Learning Style Preference (L.S. Pref.)	30.727	2	15.363	3.054	0.051*
Interactions					
School x Treatment	11.069	2	5.534	1.100	0.336
School x L.S. Pref.	20.683	2	10.341	2.056	0.133
Treatment x L.S. Pref.	3.258	4	0.815	0.162	0.957
School x Treatment x L.S. Pref.	7.925	4	1.981	0.394	0.813
School One					
Main Effects					
Treatment	16.889	2	8.444	1.601	0.211
L.S. Pref.	27.095	2	13.548	2.569	0.086
Interactions					
Treatment x L.S. Pref.	6.867	4	1.717	0.325	0.860
School Two					
Main Effects					
Treatment	11.083	2	5.542	1.149	0.323
L.S. Pref.	24.314	2	12.157	2.521	0.088
Interactions					
Treatment x L.S. Pref.	4.317	4	1.079	0.224	0.924

*Significant at $p < 0.05$.

The improved achievement in ability (or intelligence) scores and verbal analogy achievement scores was demonstrated in both groups which received instruction in critical thinking, both the self-paced and teacher-paced groups.

No significant differences were found in scores on the other sections of the Ross Test (deductive reasoning, missing premises, abstract relations, sequential synthesis, questioning strategies, relevant and irrelevant information, and attributes) (Tables 4.6 through 4.11). Although the scores on the total Ross Test were higher for the treatment groups, 60.38 and 64.33 in the teacher-paced groups, 63.24 and 59.00 in the self-paced groups than in the control groups, 56.76 and 58.67, these were not significant at the $p < 0.05$ level (Appendix C, Table C.3).

The hypothesis that achievement of higher level thinking skills are no different in teacher-paced instructional groups, self-paced instructional groups, and control groups was not supported by the significant increase in ability scores in the teacher-paced and self-paced instructional groups but not present in the control groups nor by the significant increase in verbal analogy scores in the treatment versus control groups.

The Otis-Lennon Mental Ability Test is a well-documented instrument designed to measure a general level of abstract thinking ability. Verbal analogies and figural analogies were items on this instrument most closely related to the developed instructional program. The Ross Test of Higher Cognitive Process is a more recent, experimental

instrument. The section of the test most directly related to the program of instruction was the verbal analogy section.

In comparing other subsections of the Ross Test with the instructional program, several were not covered (missing premises, sequential synthesis, questioning strategies, and relevant and irrelevant information). In examining the deductive reasoning and attribute sections, these areas were included in the instructional program but used formats different from those used in the test items. These results suggested no transfer occurred in the ability to perform thinking skills tasks not directly instructed.

On the basis of the increase in the ability (deviation I.Q.) scores of the groups which received instruction in critical thinking, and on the verbal analogy scores achieved by the instructed groups, hypothesis $H_0{}^1$ was rejected. Groups receiving teacher-paced and self-paced instruction in critical thinking achieved significantly higher scores on thinking skills measures related to the instructional program than the control groups.

Other Findings A summary of the student monitoring forms in the teacher-paced and the self-paced groups for each component of the instructional program was completed. The number of worksheets completed by students and the number of worksheets correctly completed were very similar in the two groups (Tables 4.13 and 4.14). In effect, it appeared that the average amount of material covered was essentially the same in both treatment groups. This finding supported the achievement results which were found to be comparable in the groups which received instruction in critical thinking skills versus the control

TABLE 4.13

AVERAGE NUMBER OF WORKSHEETS COMPLETED BY STUDENTS DURING INSTRUCTION IN CRITICAL THINKING SKILLS

	Treatment	
Content of Lessons	Teacher-Paced (A_1)	Self-Paced (A_2)
Introductory Activities	4.2	3.0
Verbal Analogies	6.4	5.6
Figural Analogies	13.3	12.4
Deductive Reasoning	8.3	11.8
Inductive Reasoning	6.2	9.5

TABLE 4.14

AVERAGE NUMBER OF WORKSHEETS COMPLETED CORRECTLY BY STUDENTS DURING INSTRUCTION IN CRITICAL THINKING SKILLS

Content of Lessons	Treatment	
	Teacher-Paced (A_1)	Self-Paced (A_2)
Introductory Activities	2.9	2.6
Verbal Analogies	5.6	5.2
Figural Analogies	12.3	11.4
Deductive Reasoning	7.3	10.0
Inductive Reasoning	5.4	8.6

groups. An improved achievement was not demonstrated singly in the teacher-paced or self-paced group.

The gain scores in the treatment groups from pretest to post test on the Otis-Lennon Mental Ability Test were computed for students in three pretest I.Q. (or ability) ranges: highest third (~ 82-105), middle third (~ 106-114), and lowest third (~ 82-105). The average gain in the highest and middle groups (6.0 and 6.85) was greater than in the lowest third (2.7). This finding indicated that although students scoring in all three ability ranges demonstrated an increase, those whose pretested abilities were above the mean showed greater gain than those whose scores fell below the mean.

Hypothesis $H_0{}^2$

This hypothesis states there is no significant difference on achievement of higher level thinking between groups of students differing on levels of preference for teacher-structured learning.

The mean scores and standard deviations on achievement on the Ross Test of Higher Cognitive Process and on the Otis-Lennon Mental Ability Test for groups of students differing on levels of preference for teacher-structured learning are found in Appendix C. The analysed results for the three learning style preferences (for low, moderate, or high teacher structure) effect using a three-way analysis of variance have been presented in Tables 4.1 through 4.12.

In examining learning style preference and its relationship to achievement of higher level thinking skills, those students with a preference for self-paced or self-structured learning demonstrated greater achievement in some areas. This effect was seen primarily in

the results of school B_1 where total scores on the Ross Test (Table 4.4), and the subsections of verbal analogies (Table 4.5), questioning strategies (Table 4.10), relevant or irrelevant information (Table 4.11) and attributes (Table 4.12) were significantly higher for the groups with a stronger preference for self-paced learning. School B_2 did not demonstrate this effect except in the attribute section of the test (Table 4.12). In the total sample, the only area of achievement significantly higher ($p < 0.05$) was the attribute section (Table 4.12).

Differing levels of learning style preference had no effect on the differences in pretest to post test ability scores (Tables 4.2 and 4.3).

Any advantage in achievement based on learning style preference appeared in those students who preferred self-paced, self-structured learning. Increased achievement was not demonstrated where there was a match between the instructional method and the preferred learning style, i.e. preference for self-pacing in the self-paced treatment group, or preference for teacher-pacing in the teacher-paced group.

The absence of effect of learning style preference on the results in the total sample on the Ross Test and its components, and on the Otis-Lennon measure, led to the acceptance of the second hypothesis. There are no significant differences in achievement of higher level thinking between groups of students differing on levels of preference for teacher-structured learning.

Other Findings In examining the results of the reliability analysis on the learning style preference inventory developed for this study, higher mean scores were obtained in the test-retest group used,

$\bar{x}$ = 9.5, than for subjects in the study, $\bar{x}$ = 8.5 (Appendix B). Students in test-retest classroom were in an environment where self-directed study was a primary instructional methodology. Although not appropriate for statistical analysis, this finding suggested that student response to preference for high, moderate, or low teacher-structured learning may be influenced by current instructional methodologies.

Hypothesis $H_0{}^3$

This hypothesis states there is no significant interaction between treatment and preference for teacher-structured learning.

Using the analysis of variance (ANOVA) to examine the interaction between treatment and learning style preference, no significant interaction effects were demonstrated in any subsection of the Ross Test of Higher Cognitive Processes (Tables 4.4 through 4.12), nor in the results of the ability scores on the Otis-Lennon Mental Ability Test (Tables 4.1 through 4.3) on the total sample studied.

Therefore, hypothesis $H_0{}^3$ was accepted. There was no significant interaction between treatment and preference for teacher-structured or self-structured learning.

Some interaction effects were demonstrated between school and learning style preference. In school B_1 the preference for self-structured learning resulted in higher achievement scores on the total score of the Ross Test and on the subsections of verbal analogies, questioning strategies, and relevant and irrelevant information. In school B_2 this preference did not influence achievement scores. The difference between schools resulted in the interaction effect of school and learning style preference seen in Total Ross Test scores (Table 4.4),

verbal analogies (Table 4.5), questioning strategies (Table 4.10) and relevant and irrelevant information (Table 4.11).

One interaction effect was found between school and treatment (Table 4.8). In the subsection of abstract relationships, students in self-paced preference groups in school B_1 achieved higher scores; in school B_2, students in the teacher-paced preference group achieved higher scores (Appendix C, Table C.7).

Hypothesis $H_0{}^4$

This hypothesis states there is no significant difference in the attitudes of students toward instruction of critical thinking skills between the teacher-paced group and the self-paced groups.

The means and standard deviations of scores on the attitude inventory for the two treatment groups were summarized using the SPSS BREAKDOWN Program (Appendix C). The results of an analysis of variance (SPSS ANOVA) on the responses of students to the questionnaire on critical thinking showed no significant differences between self-paced or teacher-paced treatment groups (Table 4.15). Each of ten items was analyzed as well as a total score with no significant differences on any item nor the total.

Therefore, hypothesis $H_0{}^4$ was accepted. There was no significant difference in the attitudes of students toward instruction of critical thinking between the teacher-paced group and the self-paced group.

Other Findings Student ratings on each section of the instructional program (introductory thinking skills, verbal analogies, figural analogies, deductive thinking, and inductive thinking) were tabulated (Table 4.16).

TABLE 4.15

HYPOTHESES 4, 5, 6 - ANALYSIS OF VARIANCE OF THE ATTITUDINAL RESPONSES TO CRITICAL THINKING INSTRUCTION

Question No.	Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
1	Training Style Preference	73.167	2	36.583	0.876	0.464
	Treatment	52.083	1	52.083	1.248	0.307
	Learning Style Preference x Treatment	27.167	2	13.583	0.325	0.734
2	Learning Style Preference	10.500	2	5.250	0.112	0.896
	Treatment	40.333	1	40.333	0.861	0.389
	Learning Style Preference x Treatment	48.167	2	24.083	0.514	0.622
3	Learning Style Preference	10.167	2	5.083	0.391	0.692
	Treatment	8.333	1	8.333	0.641	0.454
	Learning Style Preference x Treatment	27.167	2	13.583	1.045	0.408
4	Learning Style Preference	29.167	2	14.583	1.067	0.401
	Treatment	8.333	1	8.333	0.610	0.465
	Learning Style Preference x Treatment	8.167	2	4.083	0.299	0.752
5	Learning Style Preference	6.500	2	3.250	0.071	0.932
	Treatment	2.083	1	2.083	0.045	0.838
	Learning Style Preference x Treatment	60.167	2	30.083	0.655	0.553
6	Learning Style Preference	8.667	2	4.333	0.054	0.948
	Treatment	154.083	1	154.083	1.912	0.216
	Learning Style Preference x Treatment	16.667	2	9.333	0.116	0.898

TABLE 4.15 (continued)

HYPOTHESES 4, 5, 6 - ANALYSIS OF VARIANCE OF THE ATTITUDINAL RESPONSES TO CRITICAL THINKING INSTRUCTION

Question No.	Source of Variation	Sum of Squares	Degrees of Freedom	Mean Square	F	Significance of F
7	Learning Style Preference	47.167	2	23.583	1.951	0.222
	Treatment	30.083	1	30.083	2.489	0.166
	Learning Style Preference x Treatment	23.167	2	11.583	0.958	0.435
8	Learning Style Preference	137.167	2	68.583	2.681	0.147
	Treatment	4.083	1	4.083	0.150	0.703
	Learning Style Preference x Treatment	18.167	2	9.083	0.355	0.715
9	Learning Style Preference	15.167	2	7.583	0.229	0.802
	Treatment	8.333	1	8.333	0.251	0.634
	Learning Style Preference x Treatment	72.167	2	36.083	1.088	0.395
10	Learning Style Preference	23.167	2	11.583	0.378	0.701
	Treatment	5.333	1	5.333	0.174	0.691
	Learning Style Preference x Treatment	22.167	2	11.083	0.361	0.711
TOTAL	Learning Style Preference	90.167	2	45.083	0.080	0.924
	Treatment	850.083	1	850.083	1.504	0.266
	Learning Style Preference x Treatment	478.167	2	239.083	0.423	0.673

TABLE 4.16

RATINGS OF DIFFICULTY OF SECTIONS OF THE CRITICAL THINKING SKILLS INSTRUCTIONAL PROGRAM ON A SCALE OF 1 (VERY EASY) TO 5 (VERY DIFFICULT).

	Treatment	
Content of Lessons	Teacher-Paced	Self-Paced
Introductory Activities	3.1	2.7
Verbal Analogies	2.8	2.9
Figural Analogies	2.6	2.1
Deductive Reasoning	2.7	2.9
Inductive Reasoning	3.2	3.1

On a scale of 1 (very easy) to 5 (very difficult), the material was ranked from 2.1 to 3.1, or average difficulty. No differences were found between teacher-paced and self-paced groups. These results supported those of the attitudinal questionnaire completed at the end of the instructional program when rankings of difficulty were considered as one measure of attitude toward learning critical thinking skills.

Hypothesis $H_0{}^5$

This hypothesis states there is no significant difference in the attitudes toward instruction in critical thinking of groups of students differing on levels of preference for teacher-structured learning.

The result of the analysis of variance (SPSS ANOVA) on the responses of students to the questionnaire on critical thinking showed no significant differences between groups differing on preference for teacher-structured learning (Table 4.15). Each of ten items was analyzed as well as a total score with no significant differences on any item nor the total.

Therefore, hypothesis $H_0{}^5$ was accepted. There was no significant difference in the attitudes of groups of students differing on levels of preference for teacher-structured learning.

Hypothesis $H_0{}^6$

This hypothesis states there is no significant interaction between treatment and preference in students' attitudes.

Using the SPSS program ANOVA the interaction effects of treatment and learning style preference on students' attitude scores on the critical thinking questionnaire were analyzed. No significant interaction effects were found on any of ten items nor on the total scores

(Table 4.15). Therefore, hypothesis $H_0{}^6$ was accepted. There was no significant interaction between treatment and preference in students' attitudes.

Summary

The results of the study may be summarized according to the hypotheses tested.

An analysis of variance demonstrated that students in the groups receiving instruction in critical thinking skills (teacher-paced and self-paced) achieved significantly higher gains in deviation I.Q. scores ($p < 0.02$) on the Otis-Lennon Mental Ability Test and significantly higher scores ($p < 0.02$) on the Verbal Analogies section of the Ross Test of Higher Cognitive Processes than the control groups. These measures of achievement in thinking skills were most closely related to the instructional program in critical thinking. Although the total Ross Test scores were higher for instructed groups, they were not significant at the $p < 0.05$ level. Scores on other subsections of the Ross Test, not directly related to the instructional program, did not demonstrate significant differences in achievement between groups, suggesting no transfer occurred in the ability to perform thinking skills tasks not directly instructed.

The null hypothesis (that there was no significant difference in achievement in higher level thinking skills among the teacher-paced, self-paced, and control groups) was rejected on the basis of the significant increase in ability scores in subjects who received instruction in critical thinking and in their significantly higher verbal analogy scores. Both groups (teacher-paced and self-paced)

receiving instruction in critical thinking achieved significantly higher scores on thinking skills measures related to the instructional program than the control group.

Although there were some indications that a learning style preference for self-paced, self-structured learning resulted in greater achievement of higher level thinking skills, the results were not significant ($p < 0.05$) for the total sample in a sufficient number of measures to reject the null hypothesis. Therefore, there were no significant differences of higher level thinking skills between groups of students differing on levels of preference for teacher-structured learning (high, moderate, or low). A match between the learning style preference and teaching methodology did not result in greater achievement on thinking skills measures.

There were no significant ($p < 0.05$) interactions between treatment and learning style preference on the achievement of higher level thinking skills.

There were no significant ($p < 0.05$) differences in the attitudes of students toward instruction of critical thinkings skills between the teacher-paced and the self-paced groups. Ratings of the degree of difficulty of the materials were similar in both groups.

There were no significant ($p < 0.05$) differences in the attitudes of students differing in learning style preferences toward instruction in critical thinking. A match between learning style preference and instructional methodology did not result in differing attitudes toward the instructional program. No significant interactions between the treatment and learning style preference on attitude scores was demonstrated.

CHAPTER 5

SUMMARY AND CONCLUSIONS

Summary

The purpose of this study was to determine the effect of teacher-paced versus self-paced instruction of critical thinking skills on the achievement of higher level thinking process and student attitudes in elementary students with a high, moderate, or low preference for teacher-structured learning. The questions to be answered in the study were: (a) Can critical thinking skills be taught? (b) Does the methodology of teaching the skills affect achievement of higher cognitive process? (c) Does a match between the preferred learning style of the student and the teaching methodology make a difference in achievement? and (d) Is the attitude of students toward the instruction of critical thinking skills influenced by the teaching methodology or preferred learning style?

Review of the Literature Three theoretical models (Guilford, 1966; Piaget, 1970, 1973; & Bloom, 1956) provided the framework for developing higher cognitive process through appropriate learning experiences at the optimum stage of development. Bloom defined a construct for higher cognitive process. Guilford's model proposed components of the intellect from which thinking skills were identified for instruction. The formal operational stage of cognitive development outlined by Piaget guided the selection of the specific population for this study.

Although educators are urged to teach for thinking, research on the development of higher level intellectual skills is limited. The available

studies reviewed indicated direct instruction in logical reasoning increased student performance in higher level cognition while those using indirect methodologies were less effective. The results of studies on whether learning was more optimal when student-paced or teacher-paced were conflicting; achievement and attitude were affected in some studies, not affected in others. A review of the literature on learning styles demonstrated a significant variability in the learning or cognitive styles of students with some suggestion that a matched relationship between learning style and instructional methodology may improve student achievement.

Research Methodology

Fifth grade students (n = 135) were randomly assigned to three groups in two elementary schools, two treatment and one control, using a random block design based on a high, moderate, or low preference of students for teacher-structured learning. Trained teachers, randomly assigned, instructed students in the treatment groups in the development of critical thinking skills. A seven-week program of instruction in verbal analogies, figural analogies, deductive thinking, and inductive thinking was conducted using a curriculum guide developed for the study which contained objectives, instructional strategies, scripted lesson plans, and instructional materials. Instruction in one treatment group was teacher-paced with the material presented practiced, and corrected as a total class. Instruction in the second treatment group was self-paced where, after initial presentation, students proceeded at their own pace and corrected their own work. The control group did not receive instruction in critical thinking skills.

Following the instructional program, the achievement of higher level thinking skills was measured by the administration of the Otis-Lennon Mental Ability Test and the Ross Test of Higher Cognitive Processes to all subjects. An attitude inventory to assess student response to the critical thinking skills program was administered to the treatment groups, and student monitoring and rating forms were tabulated throughout the study.

Major Findings As a result of statistical analysis of each hypothesis, requiring significance at the $p < 0.05$ level, the findings were as follows:

1. An analysis of variance and covariance demonstrated that students in the groups receiving instruction in critical thinking skills, both self-paced and teacher-paced, achieved significantly higher scores ($p < 0.02$) than the control group on measures most directly related to instruction, the Otis-Lennon Mental Ability Test and the Verbal Analogies section of the Ross Test of Higher Cognitive Process. Scores on measures of critical thinking not directly related to the instructional program did not show significant differences between groups, suggesting no transfer occurred in the ability to perform thinking skills tasks not specifically instructed. Both instructional groups demonstrated higher ability (or intelligence) scores and higher verbal analogy achievement scores than the control group, thus indicating that the direct teaching of critical thinking skills was the key factor, not the instructional methodology.

2. In examining the effect of a student preference for high, moderate, or low teacher-structured learning, an analysis of variance

did not demonstrate significant differences ($p < 0.05$) in achievement among these learning style groups. Although there were some indications that a preference for self-paced, self-structured learning resulted in higher achievement on some thinking skills measures, the results were present only in the groups at one school, were not replicated at the second school, and did not effect scores of the total sample on sufficient achievement measures at the required level of significance. A match between the learning style preference and teaching methodology did not result in greater achievement on thinking skills measures.

There were no significant ($p < 0.05$) interactions between treatment and learning style preference on the achievement of higher level thinking skills.

3. There were no significant ($p < 0.05$) differences in the attitudes of students in the two treatment groups, self-paced or teacher-paced, toward instruction of critical thinking skills, nor did any significant differences exist in the attitudes of students with different learning style preferences. The match between student preference for high, moderate, or low teacher-structured learning and the teacher-paced versus self-paced teaching methodology did not result in differing attitudes toward the instructional program. No significant interactions between the treatment and learning style preferences on attitude measures were demonstrated.

Conclusions

The results of the major findings of the study led to the following conclusions:

1. Fifth grade students receiving direct instruction of critical thinking skills achieved higher scores than students not instructed on higher cognitive process measures specifically related to instruction, ability or intelligence and verbal analogy achievement. The transfer of critical thinking achievement to skills not specifically instructed was not demonstrated.

2. The direct teaching of thinking skills rather than the methodology was the significant factor in greater achievement on thinking skills measures.

3. A match between the preferred learning style of the student (high, moderate, or low preference for teacher-structured) and the teaching methodology (self-paced or teacher-paced) had no effect on the achievement of higher level thinking skills. On some measures of higher level thinking students with a preference for self-structured learning appeared to have an advantage.

4. The attitude of students toward the instructional program in critical thinking skills was not influenced by the teaching methodology nor by a preferred learning style.

Discussion

The significantly higher achievement of students instructed in critical thinking skills as measured by a group intelligence test and a verbal analogies measure suggested that the theoretical proposals of Sternberg (1981) and Feuerstein and Jenson (1980) -intelligence can be taught- were supported by the results of this study. This finding further suggested that intelligence (as measured by a group administered intelligence test) is neither invariant nor innate but can be affected

by specific educational experiences. Intelligence as Sternberg defines it is a composite of thinking and learning skills used in problem-solving. The data in this study suggested that exposure to and experience with specific thinking skills helped students to maximize their potential measured ability.

The lack of transfer from one type of thinking skill to another, as evidenced by the absence of effect on achievement measures of skills not directly instructed, indicates that students may require instruction in specific areas to maximize each component of the intellect as outlined by Guilford (1968). This study addressed only the semantic and figural contents and measured primarily convergent production or correct answers. The lack of transference of skills may also indicate immaturity in logical thinking processes as the subjects in this study were at the beginning of the formal operations stage outlined by Piaget (1970), when logical thinking becomes possible.

Although the instructional program was designed to teach specific critical thinking skills, standardized instrumentation available to measure these skills was limited. The inductive thinking skills which are most closely related to the synthesis level of Bloom (1956) require a measure of original or more divergent thinking. Standard tests were not useful in assessing this component of the instructional program, although informal observation by teachers indicated students appeared to utilize instructed problem solving approaches.

It was anticipated that the variation of approaches in instructing the two treatment groups would have been greater. However, using the

same content in both groups resulted in very similar types of instruction, especially as time constraints permitted only a finite amount of material to be covered in the time allocated.

The direct teaching of the skills rather than the methodology being the significant factor in the higher achievement suggested that students either adapted to the methodology, or that actual differences in methodologies were limited. Teachers were randomly assigned to the groups and followed scripted lessons, and instruction occupied only a small portion of the day. It may be that a pervasive teaching methodology or approach used on a regular basis would have an effect not demonstrated by this study.

Although the literature had suggested that attitudes could be affected by self-pacing or by preferred learning modes, no differences in attitude toward instruction were seen in groups of students in this study who had a preference for high, moderate, or low teacher-structure. Since this study was conducted for a short period each day, and used the same content, the effect of teaching methodology may have been insufficient to have an effect or it may be that most children can adapt to varied teaching styles or methodologies even though preferences may differ.

Recommendations for Future Research

In view of the results of this investigation, several recommendations are made for further research which would help to overcome the limitations of this study and increase information on the development of critical thinking skills and measures to evaluate that development, as well as on student preferred learning styles and their effect on achievement.

1. A study of the effects of teaching specific critical thinking skills at different grade levels would be useful in order to determine which skills can be optimally developed at specific age ranges.

2. Specific measures for the acquisition of higher level thinking processes are limited. Research and development in such instrumentation would be useful for work in this area at all grade levels.

3. A study where the teaching of higher level thinking skills was incorporated into content areas such as reading, science, mathematics, or social studies would be beneficial in helping to determine whether greater achievement could be obtained if skills were not taught in isolation. The transfer of thinking skills from one area to another might be assessed through this approach.

4. A study on the relationship between student learning styles and teaching methodology which is pervasive in a classroom would be beneficial in determining whether or not achievement can be improved through matching teacher and student learning style preferences.

5. A study comparing the effects of teaching different types of thinking skills would be useful in identifying the skills most important in improving higher cognitive processes. Likewise, an investigation using different materials for presentation (for example, concrete materials, worksheets, computer format, or graphic representation) could be useful in determining the most effective strategies to use in the teaching of critical thinking.

APPENDIX A

Monitoring Forms and Attitude Inventory

LET'S THINK RECORD SHEET

Name _____ School _____ Grade _____

Place a check in the box for each worksheet you complete. File your worksheets in order.

Worksheet No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Introductory Week 1																						
Verbal Analogies Week 2																						
Figural Analogies Week 3																						
Deductive Thinking Weeks 4&5																						
Inductive Thinking Weeks 5&6																						

LET'S THINK STUDENT RECORD SHEET

Name _____ School _____

Teacher _____ Grade _____

Date and Type of Activities	Number of Worksheets Completed	Number of Worksheets Correct	How Difficult Were These Activities? Very Easy	Easy	Average	Difficult	Very Difficult
			1	2	3	4	5
			1	2	3	4	5
			1	2	3	4	5
			1	2	3	4	5
			1	2	3	4	5
			1	2	3	4	5

Comments:

"LET'S THINK"

Name _____ School _____

Teacher _____ Date _____

Circle the number that best expresses how you feel toward the "Let's Think" critical thinking program in which you have been involved during the past several weeks.

The problems, lessons, and/or activities were:

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1. Interesting and held my attention	5	4	3	2	1
2. Ones that I had done before	5	4	3	2	1
3. The kind I would like to work on in the future	5	4	3	2	1
4. Done so that I worked with classmates	5	4	3	2	1
5. Never thought about except during the time given at school	5	4	3	2	1
6. Too easy	5	4	3	2	1
7. Useful in helping me to solve other problems	5	4	3	2	1
8. Studied for too long a time	5	4	3	2	1
9. Should be part of what is learned in school	5	4	3	2	1
10. Taught with too much teacher help	5	4	3	2	1

"LET'S THINK" (continued)

	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
11. Not the kind I want to do again	5	4	3	2	1
12. Worked mostly by myself without classmates	5	4	3	2	1
13. Not the kind that should be worked on in school	5	4	3	2	1
14. Studied for too short a time	5	4	3	2	1
15. Taught with too little help	5	4	3	2	1
16. Too difficult	5	4	3	2	1
17. Thought about at times other than in the work sessions	5	4	3	2	1
18. Boring and uninteresting	5	4	3	2	1
19. Probably not useful in helping me to solve other problems	5	4	3	2	1
20. Ones that I have done before	5	4	3	2	1

Comments:

A rating scale of 1 (strongly disagree) to 5 (strongly agree) was used to assess student reaction to 20 items related to the instructional program on critical thinking. Each of ten questions were written in two forms, positive and negative. Average ratings were calculated from responses to individual questions and the total to the ten questions stated in positive form. The average ratings were used to determine attitudes of the two treatment groups receiving instruction and the three types of learning style preferences in each treatment group.

APPENDIX B

Learning Style Inventory and Validation

LEARNING STYLE INVENTORY

Name _____ School _____

Date _____ Grade _____

Directions: The questions below are designed to find out how you like to learn. Each sentence below has two ways in which it can be completed. Read each sentence and both choices carefully. Then mark the choice you prefer with an "x".

1. If I have to learn something new, I like to learn about it by:

   ____ (a) having the teacher explain it.

   ____ (b) working on it by myself.

2. In working on subject assignments, I prefer:

   ____ (a) working with the teacher directing the class or group.

   ____ (b) working by myself after obtaining the assignment.

3. If I have a problem to solve, I prefer:

   ____ (a) to work on it on my own.

   ____ (b) to have the teacher show how to solve it.

4. In doing research in a subject to be presented to the class, I prefer:

   ____ (a) to work independently on a topic I choose myself.

   ____ (b) to work with a group of students on a topic suggested by the teacher.

5. When learning new material, I prefer:

   ____ (a) doing research in the library on a paper I want to write.

   ____ (b) listening to the teacher present a lesson.

6. I prefer:

   ____ (a) working on my own to prepare material I will present to the class.

   ____ (b) having the teacher ask questions on work that was assigned to be studied.

LEARNING STYLE INVENTORY (continued)

7. Usually:

____ (a) I am behind in my daily assignments.

____ (b) I have time to finish my classroom work.

8. I learn best when:

____ (a) I am evaluated with letter grades.

____ (b) I evaluate my own performance.

9. When expectations are being set for the class, I prefer:

____ (a) having the teacher make clear what is expected of the class.

____ (b) giving my ideas about what should be expected of the class.

10. I prefer:

____ (a) doing individual research in the library for a lesson or paper.

____ (b) working with a committee to complete assigned research.

11. In following a daily schedule, I prefer:

____ (a) a specific daily schedule with times defined for each subject.

____ (b) blocks of time during the day when I plan my own schedule for completing the work.

12. Once I know how to do something, I prefer to practice it by:

____ (a) working alone.

____ (b) working with the class.

13. When organizing my time, I usually:

____ (a) complete all my daily assignments.

____ (b) have difficulty completing my work each day.

14. I prefer to:

____ (a) make a presentation to the class on my own project.

____ (b) present a group project to the class.

LEARNING STYLE INVENTORY (continued)

15. When solving problems, I prefer to:

____ (a) work with the teacher on each step.

____ (b) work on my own, then check the answers.

16. When being evaluated, I prefer:

____ (a) daily quizzes on assigned work.

____ (b) turning in long term projects I have designed for grading.

The learning style preference inventory was scored by assigning one point to a preference for self-structured learning and zero points to a preference for teacher-structured learning. On the 16 item inventory, the range of scores was three to fifteen, the mean was 8.5, and the standard deviation 2.6. Students with scores in the 11 to 15 range were classified as learning style preference one, or a low preference for teacher-structure; scores in the 7 to 10 range as learning style two, or moderate preference for teacher-structure; and scores in the 3 to 6 range as a high preference for teacher structure.

TABLE B.1

LEARNING STYLE INVENTORY VALIDATION

Test-Retest Correlation

	N	Mean	Standard Deviation
Test	24	9.5	2.6
Retest	24	9.5	2.5

Pearson Correlation Coefficient = 0.86

Internal Consistency

	N	Mean	Standard Deviation
First 8 Items	63	3.9	1.5
Second 8 Items	63	4.6	1.7
Total 16 Items	63	8.5	2.6

Correlation Between Learning Style and Locus of Control

	N	Mean	Standard Deviation
Learning Style	70	8.7	2.6
Locus of Control	70	24.64	3.8

P = 0.22

APPENDIX C

Mean Scores and Standard Deviations of Scores on Pretest and Post-Test Measures of Higher Level Thinking Skills

TABLE C.1

MEANS AND STANDARD DEVIATIONS OF SCORES ON
PRETEST SCORES ON THE OTIS-LENNON MENTAL ABILITY TEST

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	114.800	7.791	117.000	14.950	107.200	9.471
	L.S.P.C_2	113.417	11.595	109.167	6.379	111.750	8.103
	L.S.P.C_3	105.250	18.679	104.500	8.963	104.500	9.883
	TOTAL	112.191	12.274	110.143	9.891	109.286	8.833
School B_2	L.S.P.C_1	108.600	7.469	113.400	16.502	106.400	9.555
	L.S.P.C_2	108.000	14.093	108.857	15.377	111.357	11.119
	L.S.P.C_3	115.000	13.323	100.200	7.085	108.800	10.918
	TOTAL	109.583	12.687	108.000	14.482	109.792	10.521

L.S.P.C_1 = Learning Style Preference for Low Teacher Structure.

L.S.P.C_2 = Learning Style Preference for Moderate Teacher Structure.

L.S.P.C_3 = Learning Style Preference for High Teacher Structure.

TABLE C.2

MEANS AND STANDARD DEVIATIONS OF SCORE GAINS FROM PRETEST TO POST TEST ON THE OTIS-LENNON MENTAL ABILITY TEST

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	7.000	6.670	5.000	5.339	2.000	6.964
	L.S.P.C_2	3.917	5.823	8.083	9.558	-0.917	5.418
	L.S.P.C_3	1.500	9.469	5.500	5.802	5.000	2.828
	TOTAL	4.191	6.668	6.857	7.945	0.905	5.718
School B_2	L.S.P.C_1	8.000	7.618	2.600	4.980	2.600	5.103
	L.S.P.C_2	1.857	6.125	4.500	6.699	1.000	4.722
	L.S.P.C_3	5.800	7.629	5.400	3.209	5.600	5.477
	TOTAL	3.958	6.109	4.292	5.691	2.292	3.209

TABLE C.3

MEANS AND STANDARD DEVIATIONS OF TOTAL SCORES ON
THE ROSS TEST OF HIGHER COGNITIVE PROCESSES

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	67.200	11.212	71.400	11.971	57.200	6.686
	L.S.P.C_2	61.250	11.185	62.750	13.792	57.583	10.423
	L.S.P.C_3	49.250	10.782	54.500	13.478	53.750	11.117
	TOTAL	60.381	12.175	63.238	13.877	56.762	9.460
School B_2	L.S.P.C_1	69.600	2.966	58.200	5.450	59.800	11.649
	L.S.P.C_2	59.642	10.551	60.429	11.765	56.929	9.627
	L.S.P.C_3	72.200	10.568	55.800	8.983	62.400	10.015
	TOTAL	64.333	10.805	59.000	10.052	58.667	9.929

Total Sample : Mean = 60.42, Std. Dev. = 11.20, n = 135.

Ross Technical Report: Mean = 57.65, Std. Dev. = 14.13, n = 80.

TABLE C.4

MEANS AND STANDARD DEVIATIONS OF VERBAL ANALOGIES SCORES ON THE ROSS TEST OF HIGHER COGNITIVE PROCESSES

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	10.600	1.67	10.800	2.168	8.200	1.304
	L.S.P.C_2	10.333	2.871	9.250	1.950	8.500	2.236
	L.S.P.C_3	7.500	1.915	8.000	1.633	5.750	2.872
	TOTAL	9.857	2.651	9.381	2.085	7.905	2.343
School B_2	L.S.P.C_1	8.800	1.483	7.600	1.673	8.600	2.510
	L.S.P.C_2	9.643	2.500	9.500	1.698	8.857	2.179
	L.S.P.C_3	11.400	1.817	9.600	1.673	8.400	1.673
	TOTAL	9.833	2.300	9.125	1.801	8.703	2.074

Total Sample : Mean = 9.14, Std. Dev. = 2.27, n = 135.

Ross Technical Manual Report: Mean = 7.46, Std. Dev. = 2.50, n = 80.

TABLE C.5

MEANS AND STANDARD DEVIATION OF DEDUCTIVE REASONING SCORES ON THE ROSS TEST OF HIGHER COGNITIVE PROCESSES

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	12.400	1.140	13.400	0.894	12.200	3.633
	L.S.P.C_2	12.500	2.067	11.500	3.344	11.333	2.425
	L.S.P.C_3	11.500	3.697	9.250	4.992	12.000	0.817
	TOTAL	12.286	2.194	11.524	3.459	11.667	2.477
School B_2	L.S.P.C_1	14.200	1.483	12.000	1.414	12.200	1.095
	L.S.P.C_2	11.357	2.735	12.929	2.841	10.714	2.644
	L.S.P.C_3	14.200	1.924	11.600	3.647	11.400	3.435
	TOTAL	12.542	2.702	12.458	2.750	11.167	2.565

Total Sample : Mean = 11.95, Std. Dev. = 2.71, n = 135.

Ross Technical Manual Report: Mean = 11.79, Std. Dev. = 3.11, n = 80.

TABLE C.6

MEANS AND STANDARD DEVIATIONS ON MISSING PREMISES SCORES ON THE ROSS TEST OF HIGHER COGNITIVE PROCESSES

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	4.600	1.949	3.600	1.140	3.200	1.483
	L.S.P.C_2	3.417	1.929	4.583	1.505	3.500	1.679
	L.S.P.C_3	2.000	0.817	2.750	2.217	3.250	0.957
	TOTAL	3.429	1.912	4.000	1.673	3.381	1.466
School B_2	L.S.P.C_1	4.200	1.304	3.400	1.817	3.600	1.140
	L.S.P.C_2	3.786	1.528	3.714	0.825	3.071	1.542
	L.S.P.C_3	3.600	1.673	2.800	1.926	3.800	1.304
	TOTAL	3.833	1.467	3.485	1.318	3.333	1.404

Total Sample : Mean = 3.57, Std. Dev. = 1.53, n = 135.

Ross Technical Report: Mean = 3.50, Std. Dev. = 1.70, n = 80.

TABLE C.7

MEANS AND STANDARD DEVIATIONS ON ABSTRACT RELATIONSHIPS SCORES ON THE ROSS TEST OF HIGHER COGNITIVE PROCESSES

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	8.800	5.020	11.200	3.564	8.800	2.388
	L.S.P.C_2	10.083	3.423	11.583	2.021	9.833	2.855
	L.S.P.C_3	7.000	2.160	9.750	3.948	9.750	2.061
	TOTAL	9.191	3.696	11.200	2.762	9.571	2.541
School B_2	L.S.P.C_1	12.800	0.837	9.400	3.050	10.000	5.385
	L.S.P.C_2	10.214	2.607	9.714	4.531	9.714	3.338
	L.S.P.C_3	11.800	2.683	7.600	3.975	9.800	3.271
	TOTAL	11.083	2.535	9.208	4.086	9.792	3.635

Total Sample : Mean = 10.00, Std. Dev. = 3.32, n = 135.

Ross Technical Report: Mean = 9.84, Std. Dev. = 3.42, n = 80.

TABLE C.8

MEANS AND STANDARD DEVIATIONS ON SEQUENTIAL SYNTHESIS SCORES ON THE ROSS TEST OF HIGHER COGNITIVE PROCESSES

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	3.000	2.739	4.800	3.271	2.200	2.388
	L.S.P.C_2	2.750	2.491	3.000	3.191	3.083	2.314
	L.S.P.C_3	1.000	1.155	2.250	3.304	1.750	2.363
	TOTAL	2.476	2.400	3.286	3.196	2.619	2.291
School B_2	L.S.P.C_1	4.000	3.391	2.600	1.517	4.200	4.087
	L.S.P.C_2	1.857	2.713	2.643	3.104	3.429	3.106
	L.S.P.C_3	4.400	3.209	1.800	1.643	4.200	3.564
	TOTAL	2.833	3.060	2.458	2.536	3.750	3.274

Total Sample : Mean = 2.91, Std. Dev. = 2.81, n = 135.

Ross Technical Report: Mean = 3.10, Std. Dev. = 2.77, n = 80.

TABLE C.9

MEANS AND STANDARD DEVIATIONS OF QUESTIONING STRATEGIES SCORES ON THE ROSS TEST OF HIGHER COGNITIVE PROCESSES

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	9.600	1.342	9.200	1.483	7.000	1.581
	L.S.P.C_2	7.500	2.576	6.750	2.864	6.750	2.701
	L.S.P.C_3	6.750	2.217	7.000	2.450	7.000	2.828
	TOTAL	7.857	2.414	7.381	2.686	6.857	2.393
School B_2	L.S.P.C_1	8.600	1.767	6.600	1.673	7.200	1.304
	L.S.P.C_2	8.214	1.673	8.071	2.303	7.143	2.349
	L.S.P.C_3	9.600	1.968	7.600	1.673	8.600	1.140
	TOTAL	8.583	0.894	7.667	2.078	7.458	1.999

Total Sample : Mean = 7.65, Std. Dev. = 2.24, n = 135.

Ross Technical Report: Mean = 6.06, Std. Dev. = 2.78, n = 80.

TABLE C.10

MEANS AND STANDARD DEVIATIONS OF RELEVANT AND IRRELEVANT INFORMATION SCORES ON THE ROSS TEST OF HIGHER COGNITIVE PROCESSES

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	7.400	0.894	7.000	1.225	5.800	1.483
	L.S.P.C_2	5.083	1.881	5.750	1.765	4.833	1.115
	L.S.P.C_3	5.000	3.559	6.250	1.500	5.250	3.594
	TOTAL	5.619	2.247	6.143	1.621	5.143	1.799
School B_2	L.S.P.C_1	5.800	1.643	5.000	2.000	5.600	1.949
	L.S.P.C_2	5.286	1.899	5.643	1.945	5.357	1.598
	L.S.P.C_3	6.200	1.309	6.400	1.342	5.400	2.510
	TOTAL	5.583	1.717	5.667	1.857	5.417	1.792

Total Sample : Mean = 5.59, Std. Dev. = 1.83, n = 135.

Ross Technical Report: Mean = 5.98, Std. Dev. = 2.23, n = 80.

TABLE C.11

MEANS AND STANDARD DEVIATIONS OF ANALYSIS OF ATTRIBUTES SCORES ON THE ROSS TEST OF HIGHER COGNITIVE PROCESSES

		TREATMENT					
		A_1		A_2		A_3	
	Learning Style Preference	Teacher-Paced		Self-Paced		Control	
		Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
School B_1	L.S.P.C_1	10.800	1.924	11.400	2.302	9.800	3.033
	L.S.P.C_2	9.583	1.782	10.333	2.708	8.917	2.353
	L.S.P.C_3	7.750	2.062	9.250	0.500	9.000	2.708
	TOTAL	9.524	2.040	10.381	2.376	9.143	2.476
School B_2	L.S.P.C_1	10.600	3.050	10.600	1.673	9.400	1.673
	L.S.P.C_2	9.286	2.302	8.857	1.995	8.643	2.274
	L.S.P.C_3	11.000	2.345	9.600	1.342	9.400	2.608
	TOTAL	9.918	2.488	9.875	1.884	8.958	2.177

Total Sample : Mean = 9.54, Std. Dev. = 2.26, n = 135.

Ross Technical Report: Mean = 9.92, Std. Dev. = 2.38, n = 80.

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ABSTRACT

THE EFFECT OF CRITICAL THINKING SKILLS INSTRUCTION ON ACHIEVEMENT AND ATTITUDES OF ELEMENTARY STUDENTS DIFFERING IN LEARNING STYLE PREFERENCES

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The College of William and Mary in Virginia, December 1983

Chairman: Professor Royce W. Chesser

The purpose of this study was to determine the effect of teacher-paced versus self-paced instruction of critical thinking skills on the achievement of higher level thinking process and student attitudes in elementary students with a high, moderate, or low preference for teacher-structured learning.

Fifth grade students (n=135) were randomly assigned to three groups in two elementary schools, two treatment and one control, using a random block design based on a high, moderate, or low preference of students for teacher-structured learning. Trained teachers, randomly assigned, instructed students in the treatment groups in the development of critical thinking skills. A seven-week program of instruction in verbal analogies, figural analogies, deductive thinking, and inductive thinking was conducted using a curriculum guide developed for the study which contained objectives, instructional strategies, scripted lesson plans, and instructional materials. Instruction in one treatment group was teacher-paced with the material presented, practiced, and corrected as a total class. Instruction in the second treatment group was self-paced where, after initial presentation, students proceeded at their own pace and corrected their own work. The control group did not receive instruction in critical thinking skills.

The major findings of the study were: (1) Students in the groups receiving instruction in critical thinking skills, both self-paced and teacher-paced, achieved significantly higher scores ($p < 0.02$) than the control group on measures most directly related to instruction, ability or intelligence and verbal analogy achievement. The direct teaching of the skills rather than the methodology was the significant factor in greater achievement of higher level thinking processes. Scores on measures of critical thinking not directly related to the instructional program did not show significant differences between groups, suggesting no transfer occurred in the ability to perform thinking skills tasks not specifically instructed. (2) Although there were indications that a preference for self-paced, self-structured learning resulted in higher achievement on some thinking skills measures, the results were not statistically significant. A match between learning style preference and teaching methodology did not result in greater achievement on thinking skills measures. (3) There were no significant differences in the attitudes of students in the two treatment groups, self-paced or teacher-paced, toward instruction of critical thinking skills, nor did any significant differences exist in the attitudes of students with different learning style preferences.