INTERACTION OF MATHEMATICS APTITUDES WITH LOGO INSTRUCTIONAL TREATMENTS IN A COLLEGE EDUCATIONAL COMPUTING COURSE

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CHAPTER I

INTRODUCTION

The Research Problem

Computers are changing how colleges look, how they operate, but most importantly how professors teach and students learn. Teaching programming has traditionally been one way to integrate computers into the college curriculum. Many colleges of education require a computing course as a part of technology training for pre-service teachers (Bruder, 1989). The role of programming in these courses has been questioned (Thompson and Friske, 1988).

Logo has been used as one of computer programming languages taught in college introductory computing courses. Logo was developed to enhance intellectual functioning for children as well as adults. Papert (1980) has argued that as students of all ages learn Logo they develop ways of thinking and solving problems that will help them in other areas. This claim about potential benefits of Logo has generated considerable enthusiasm due to a growing concern about the need for schools to develop effective thinking and problem-solving skills (Bransford & Stein, 1984; Segal et. al., 1985).

Need for the Study

Microcomputer Technologies in Education is a required introductory computing course for undergraduate students in the college of education at Oklahoma State University. The course was designed for students with little or no prior experience with microcomputers and related technologies. The course has three basic components: 1) computer literacy-a general knowledge of computer terminology and operations; 2) instructional applications - a general knowledge of software/hardware applications utilized as personal and teaching tools; and 3) programming - a general knowledge of the principles involved in programming microcomputers. Logo and BASIC are the two languages that have been taught within the course. Emphasis has been placed on programming as a problem solving process rather than on the commands and procedures specific to a particular computer language.

The programming content of the course has been the most difficult part of the course for the majority of college students. Based on observations, the investigator found that students with poor attitudes and weak skills in mathematics had difficulty programming in Logo. However, students possessing favorable attitudes and strong capabilities in mathematics captured the language very easily.

The research has shown that programming in Logo is closely related with how students learn mathematics (Feurzeig and Lukas, 1972; Hatfield, 1979; and Ross and

Howe, 1981). According to Hatfield

> Mathematics learning is primarily a person-centered, constructive process; students build and modify their knowledge from experiences with task-oriented situations characteristic of mathematics. Students must experience opportunities and develop feelings of responsibility for revising, refining, and extending their ideas as the ideas are being constructed (p. 53).

One approach reinforcing this "constructive" view for building mathematical concepts and problem solving skills can be developed or enhanced by asking them to instruct the computer to do some type of mathematical task. A natural choice for a computer environment in which students can be actively engaged in constructing and exploring mathematics is Logo. According to Feurzeig and Lukas (1972), Logo provides an operational universe within which students can define a mathematical process and then see its effects unfold. Several research studies have reported Logo programmers' gains in learning certain mathematical topics (Ross and Howe, 1981).

Kinzer, et. al. (1985) argued that different instructional techniques in Logo have resulted in different amounts of learning. A popular method of instruction in Logo has involved the open, discovery method of teaching. The reasons for teaching Logo in this way was based on observations of children who appear to be successful at learning generalizable thinking skills when taught Logo in this type of environment (Papert, 1980). These observations have led to claims that the open method of teaching Logo is an effective one. Research in other areas has indicated that instructional methods have a major influence on what is learned (Arbitman-Smith, et. al., 1984).

Aptitude treatment interaction (ATI) studies have been concerned with the differential effects of various instructional styles and learner characteristics on achievement. The underlying assumption of ATI is that differences exist in learning patterns and that no one method of instruction is best for all learners. One goal of ATI research has been to identify student characteristics that will predict learning outcomes dependent upon instructional approaches.

Educators have investigated the relationship between many individual characteristics and treatments, and its effect on the learning process. Examining over 400 ATI studies, Cronbach and Snow (1977) have affirmed the existence of interactions between aptitudes and instructional treatments. Cronbach (1957) predicted that ATI research

> Will carry us into an educational psychology which measures readiness for different types of teaching and which invents teaching methods to fit different types of readiness. In general, unless one treatment is clearly best for everyone, treatments should be differentiated in such a way as to maximize their interaction with aptitude variables (p. 681).

In the last twenty years, ATI research in mathematics education has focused primarily on the interaction between the aptitudes, general reasoning ability and locus of control, and differing types of instructional methods. Reviewing these studies, general reasoning ability (GRA), measured by the Necessary Arithmetic Operations (NAO) test (French, et. al., 1963), has interacted significantly with various instructional treatments in predicting mathematics achievement. Studies supporting this finding were Carry (1968), Eastman (1972), Salhab (1973), DuRapau (1979), Hickey (1980), and Friske, (1982).

ATI research involving locus of control (LOC) measured by various adaptations of Rotter's I-E Scale (1966) has reported mixed findings. Daniel and Stevens (1976), Hickey (1980) and Horak and Slobodzian (1980) found that LOC interacted significantly across instructional treatments in predicting achievement. Several studies reviewed by Lefcourt (1976) and Phares (1976) (reporting non-significant findings) indicated the need to measure LOC within a particular content area Hickey (1980).

Treatment characterizations for ATI research in mathematics education have varied. In the studies mentioned previously (Carry 1968; Eastman 1972; Salhab 1973; DuRapau 1979; Hickey 1980 and Friske 1982), treatment types such as graphical versus analytical, geometric versus algebraic, and inductive versus deductive have all interacted significantly with general reasoning ability. In addition, other studies (Hickey 1980; Peterson, 1977; and Winne, 1977) reported that low support versus high support treatments have interacted significantly with locus of control. These and similar results found in ATI research have provided a foundation for clarifying the treatment characterizations that interact with particular aptitudes in the mathematics learning process (Duran, 1985).

Maddux (1984) stated that the most critical need in educational computing is a strong research base, and indicated such a base was lacking in educational computing, particularly in Logo. Further research is needed to clarify the effect of different methods of teaching Logo in building mastery of the language across different instructional situations. This study addressed building a knowledge base related to understanding the effects of Logo on students at the college level.

Statement of the Problem

The primary purpose of this study was to investigate the relationship between the aptitudes general reasoning ability and locus of control in mathematics and two instructional treatments for developing Logo concepts in college level students. A secondary purpose of this study was to provide information to assist in planning and adapting instruction in Logo to the individual differences of college students enrolled in an introductory computing course.

The following questions concerning the relationship between the selected learner aptitudes and instructional treatments were considered.

1. Do students exhibit a better understanding of the Logo in a low structure treatment or high structure treatment?

2. Are the aptitudes, locus of control in mathematics, and general reasoning ability differential predictors of Logo achievement across two instructional treatments?

3. Do students who are high in the aptitudes exhibit a better understanding of Logo language studied under a low structure treatment?

4. Do students who are low in the aptitudes exhibit a better understanding of Logo language studied under a high structure treatment?

To investigate these questions an aptitude treatment interaction study was conducted. The predictor variables selected were general reasoning ability and locus of control in mathematics. These variables were measured by the Necessary Arithmetic Operations test (French, et. al., 1963) and the Mathematics Attitude scale (Hickey, 1981). The dependent variable for this investigation was the score achieved by the student on the Logo test. Low structure and high structure treatments were chosen as the instructional styles to be utilized for teaching Logo. The knowledge gained from this study can be expected to assist in planning instruction, and in adapting instruction to the individual differences of college students enrolled in an introductory computing course.

Definitions

Treatment: The treatment is an instructional approach that elicits certain types of mental functioning within the learner (Cronbach and Snow, 1977).

Low Structure Treatment: The instructional style in which general objectives are stated, theoretical considerations are discussed, and the learner must sort information to arrive at his/her own meaningful inferences. This could be described as a discovery or inductive approach to teaching (Hickey, 1980).

High Structure Treatment: The instructional style in which specific objectives are stated, computational aspects are stressed, and the student is guided to mastery of concepts and skills. This could be described as an expository or didactic approach to teaching (Hickey, 1980).

Aptitude: Any characteristic of a person that forecasts the individual's probability of success under a given treatment (Cronbach and Snow, 1977).

General Reasoning Ability (GRA): Based on the work of Guilford (1967, 1971), individuals exhibit a high degree of GRA when they can extrapolate and synthesize from their own experiences and knowledge to deal with an unfamiliar situations. Guilford (1971) defined general reasoning as "the ability to conceive of structures, of which an arithmetical problem is a good example, if that structure is sufficiently complex" (p. 96).

Locus of Control in Mathematics (LOC-MTH): Based on the work of Rotter (1966) and modified by Hickey (1981), Locus of control in mathematics is a generalized expectancy in mathematics determined by the degree to which the individuals perceive the relationship between outcomes and reinforcements to result of fate, chance, or external forces around themselves.

Logo: Based of the work of Papert Logo is a family of computer languages that was designed to make computer programming as easy as possible to understand (Papert, 1980). This study employed the LogoWriter version of Logo designed by Logo Computer Systems, Inc.

Summary

Logo, has been utilized as the programming language for introductory college of education computing courses. The research base examining the effects of integrating Logo using different instructional styles at the college level has been inadequate. The primary emphasis has been placed at the elementary level. Maddux (1984) stressed the importance of building a strong research base in educational computing in order to understand how to utilize the computer to adopt instruction to meet individual needs.

Learning Logo has been correlated closely to learning mathematics (Hatfield, 1979). Based on the observations, the investigator identified characteristics of those students who responded positively to an open discovery approach to learning Logo as well as learner characteristics of those students who responded positively to a more structured Logo environment.

The purpose of aptitude treatment interaction (ATI) has been to adopt instructional treatments to individual learner aptitudes. ATI studies have been concerned with the differential effects of various instructional styles and learner characteristics on achievement. ATI research in mathematics education has focused primarily on the interaction between the aptitudes, general reasoning ability, locus of control, and differing types of instructional methods.

This study examined the relationship between the general reasoning ability and locus of control in mathematics and instructional treatments for developing Logo concepts in college level students.

CHAPTER II

RELATED LITERATURE AND RESEARCH

This chapter has been organized in three sections: theory and research concerning Logo; conceptualization of aptitudes and treatments; and supporting aptitude treatment interaction (ATI) research.

Overview of Research Concerning Logo

Introduction

Papert (1984) stated that within the next decade everyone should have a computer and use it for just about everything. Technology has promoted new educational methods more rapidly than educators can learn to use them (Watt, 1984b). Bork (1987) believed that technology would improve education if it is used well. He pointed out the integration of technology into our educational system should 1) make education enjoyable; 2) make education active; 3) make education individualized; 4) achieve mastery in education and 5) make the results of education known.

The microcomputer has been praised highly as the teaching tool that will help children think and learn more effectively and efficiently than ever before. Computer literacy has been the issue schools are addressing. Fiske (1983) believed that the main areas of computer literacy includes computer operations, computers in our society, computer programming, and computer ethics. Computer literate students will be able to think and solve problems, understand how a computer functions, and utilize many computer applications.

Bennett (1984) pointed out the real goal of computer programming education has been to become literate in the usage of a language. Questions have been raised about what computing experiences have been best for children. Additional issues have been concerned with how much time should be allotted to each topic, when each topic should be introduced, and what learner benefits can reasonably be expected from these topics. Computer educators have agreed that programming in some form or fashion should be taught in the schools. Disagreement has existed concerning why learning to program is important and what language is most appropriate at specific ages (Wold, 1983).

According to Tinker (1983) the best programming component for the computer literacy curriculum is to teach Logo to beginning students, change to an intermediate language and then teach Pascal for an applications language. Watt (1983) reflected the potential of Logo in our schools as follows:

> With its ease of use, exciting applications, and educational benefits, Logo may someday replace BASIC as a universal first

> programming language. Logo's suitability for structured programming and modular problem solving may also lead to its use in introductory computer science courses (p. 106).

Statz (1973) was one of the first researchers to empirically consider the benefits of teaching Logo to children. He suggested that learning Logo facilitates the growth of more general problem-solving skills.

The computer programming language Logo was originally developed in 1968 as part of a National Science Foundation sponsored research project conducted at Bolt, Beranek and Newman, Inc. in Cambridge, MA (Feurzeig et. al., 1969). Logo was derived from a high-level language used in the field of Artificial Intelligence, called LISP. Logo began to emerge in its present form under the direction of Papert at Massachusetts Institute of Technology (MIT) from 1970 to 1981. The MIT Logo research group was composed of members from the MIT Division for Study and Research Group in Education. The research was conducted mostly in a laboratory setting at MIT because Logo required considerable memory capabilities of a computer.

Seymour Papert (1980), Logo's principal developer and advocate, saw computer programming as a means of enhancing intellectual functioning. Specifically he developed the Logo system as a computer-based learning environment in which students can develop an awareness of themselves as thinkers and learners as they learn computer programming. He was influenced by the theories and work of Jean Piaget with whom he studied for five years. Logo was the result of combining the capabilities of artificial intelligence with the theories of Piaget in order to allow a learner to build his own intellectual structures through estimation, interaction, experience, and revision (M. Watt, 1982).

Logo, as envisioned by Papert (1980), has no ceiling, no threshold. The extent of personal involvement and the depth of intellectual skills used for programming in Logo has been examined in research. Logo has been suitable for a wide variety of individual students. It has been enthusiastically used with three year olds (Nelson, 1981), undergraduate psychology classes, and junior high, elementary, and kindergarten children (Lemmons, 1982). Its educational value has been investigated with physically handicapped, emotionally disturbed, and mentally retarded students (Weir, 1982).

Research on Logo Programming

Logo research in the United States originated at MIT under the leadership of Seymour Papert. Other Logo research leaders include Harold Abelson, Andrea di Sessa, Marvin Minsky and Wallace Feurzeig from Bolt, Beranek and Newman, Inc. (Fiske, 1983). The publication of Mindstorms in 1980 (Papert), coupled with the increased availability of microcomputers in the schools, has stimulated more independent research on this topic.

The Brookline Logo Project

One of the first indepth research studies on Logo was the Brookline project (Papert, et. al., 1979; and Watt, 1979). The Brookline project was carried out by the MIT Logo group during 1977-78. Papert, et. al. (1979) examined the degree to which children learn to program the Logo turtle, the degree to which the programming experience of the subjects would help them to master the mathematical concepts embodied in the language, and the degree to which the Logo programming experience would help children develop problem solving skills using debugging strategies. No significant differences were found. Lengthy reports of each individual student's success with Logo could provide teachers a foundation to base for other Logo projects.

The second Brookline project, focused on the development of a curriculum supporting classroom use of Logo (Papert et. al., 1979). Results of the children's involvement with Logo were presented as a breakdown of the mathematical skills and concepts, and programming skills and concepts to which the children were exposed during the project. The students using Logo in the Brookline Project did better on angle and line estimation than other students with a different computer experience, and than those students with no computer experience.

Three conclusions were formulated based on the Brookline projects:

1. CAI has its place in the regular curriculum, but it

is inadequate as a major part of computer education and the computer literacy program.

2. BASIC is too difficult for the average fourth, fifth and sixth graders.

3. Logo has the elements for a comprehensive computer program since it teaches programming, uses graphics, and provides new approaches to problem solving (Markuson et. al., 1983).

The Lamplighter Project

In 1980, a four-year project for children ranging from three to nine years of age was initiated at the Lamplighter School, a private school in Dallas, TX. The project began under the supervision of Seymour Papert and the MIT Logo Research Group in collaboration with the school and Texas Instruments. A major objective was to determine if Logo could be used by students to learn better thinking, problem-solving, and learning skills.

The investigation found that Logo helped students to: (1) develop logical thinking and problem solving skills; (2) learn to develop and test their own ideas and theories; and (3) become familiar with concepts such as variables, symmetry, angles, and geometric forms.

Other Logo Projects

At a private school connected with the University of Edinburgh, Edinburgh, Scotland, 12 and 13 year old boys dealt with Logo. The objective of the project was to discover whether the students' ". . . ability to do mathematics was changed by exploring mathematical problems through Logo programming" (Howe, et. al., 1978). Specifically, they looked at students' ability to do mathematics and to talk about their mathematics. The research was structured through instructional materials and standardized testing. The project extended over two years and included the collection of informal data about what and how the students learned. Improvement in the mathematical understanding of the experimental group was found in addition to the general improvement in mathematical communication and articulation.

Third grade students were the subjects in a study by Gorman and Bourne (1983). Fifteen students learned Logo during the school year in one hour per week of individual computer time. Those students performed better on a conditional rule-learning task than did a comparable group who received one-half hour per week of individual computer time. Both groups received in-class instruction.

Logo learners at Queen's University in Kingston, Ontario, in a non-systematic series of encounters with programming, ranged in age from six to the various ages of the education faculty. The intention of the project was to familiarize anyone in the community interested in Logo with the language. A consensus among the learners appeared on two issues: 1) the claims made by Papert as the Logo's educational value are sound; and 2) a great deal of training will be necessary for teachers to successfully use Logo to develop higher thinking skills (Higginson, 1982).

Some research has been conducted on Logo's effect upon cognitive styles. Young (1982) attempted to analyze the effect of the Logo computer programming environment upon the reflective and impulsive cognitive styles of second-grade students. Using a pre-posttest, experimental design, she found that more of the students in the experimental Logo class shifted in the direction of reflective thinking than did those students in the control group. She also found that all of the twelve experimental group students were successful in controlling the computer in the Logo environment. It was reported that all were able to design computer programs while developing self-confidence in their abilities and pride in their accomplishments.

Papert has proposed that development of thinking skills is a possible way to enhance a student's future learning in general situations. The results of research to test these claims are conflicting. The best designed and executed studies to date on the types and amount of cognitive change to be anticipated from computer programming within a Logo environment were conducted by researchers (Pea, 1983; Pea & Kurland, 1983a) at the Bank Street College center for children and technology. They indicated that there is little, if any, transfer of learning from the Logo situation to similar non-Logo tasks. Pea and Kurland (1983b) stated that knowledge about prerequisite mental abilities that allow for the development of high-level programming skills in pre-college-age students is completely anecdotal. They reported that six factors are frequently mentioned in the literature on the subject: mathematical ability, processing capacity, analogical reasoning, conditional reasoning, procedural thinking, and temporal reasoning.

Studies by (Gorman and Bourne, 1983; and Clements, 1985) have shown that Logo has had positive effects on the development of cognitive and metacognitive skills and academic achievement. Clements, et. al. (1984) found a relationship between success on Logo tasks and metacognitive abilities, reflectivity, field independence, processing capability, classification and serration abilities, mathematics achievement, and originality errors.

In the study by Horton and Ryba (1986), sixteen junior high school students were assigned randomly to Logo and non-Logo groups. The non-Logo group received no treatment apart from the regular school program, whereas the Logo group was given the Assessing Learning With Logo program on an after-school basis. All students were individually assessed before and after training on these six tasks; Exploration, Analysis and Planning, Creativity, Debugging, Coding, and Prediction. Working in pairs, the Logo students were given two one-hour Logo sessions each week over a seven-week period of instruction.

During this time, they progressed individually through each of the Logo levels including basic Turtle commands, REPEAT commands, defining procedures, editing and system operating, sub-procedures and super-procedures. Students advanced according to their abilities to master the thinking skills and programming operations. No student progressed to the next Logo level until all the thinking skills at a previous level were acquired. They then spent two weeks working on individual Logo projects which required them to create a drawing of their own choice by planning and analyzing the steps to completion and then programming the drawing in Logo.

Progress records for each student were kept using the thinking skills checklists contained in the Assessing Learning With Logo method. The checklists provided a system for: (1) assessing the development of each learner's thinking skills; (2) assessing the progress of a group of learners; and (3) deciding upon the content and organization of activities to be included in each subsequent Logo session.

The findings indicated that the Logo group tended to outperform the non-Logo group on all tasks with the exception of the Checking Test. The results have suggested that the focus on development of specific thinking skills using Assessing Learning With Logo can enhance students' cognitive development.

LogoWriter (Papert, 1986) a version of Logo, includes four Turtles and all the capabilities of "traditional" Logo, as well as word processing and music. Additional features include changing the Turtle's shape, stamping shapes, and filling areas with patterns or solid colors.

Bearden (1986), used LogoWriter in an after-school class for eight weeks, with 60 fifth and sixth grades in McKiney, TX. During the first few sessions, students were introduced to the Turtle, word processing, simple animation, and mixing text and graphics. Students wrote procedures to have the Turtle assume one shape and then the other, creating an illusion of movement or animation.

Bearden found that LogoWriter allowed a greater diversity of ideas and projects to be created much more quickly than with regular Logo. It offered more creative options and allowed different learning styles, personalities, and interest.

People in the classroom teaching Logo are not computer programmers. Most teachers need not only learn the language of Logo, but also to learn how to implement Logo and create a Logo environment in the classroom (Riordan, 1982). "Knowing when and when not to intervene seems to be the secret of artful Logo teaching" (Moore, 1983, p. 14). Logo teachers are an integral part of the learning process and must help students see the connections between different situations (Dale, 1984).

Aptitude Treatment Interaction

Introduction

Aptitude treatment interaction (ATI) research has as its broadest goal to adapt instructional treatments to individual learner aptitudes. ATI studies have been concerned with the differential effects of various instructional styles and learner characteristics on achievement. The underlying assumption of ATI is that differences exist in learning patterns and that no one method of instruction is best for all learners.

> The general framework for this type of research comes from the work of Cronbach (1957) when he observed that: A person learns more easily from one method than another, that this best method differs from person to person, and that such between-treatment differences are correlated with tests of ability and personality (p. 681).

The aim of research in this area is to determine what "best" linear relationship - if any - between aptitudes and certain types of achievement can be obtained through planned instructional techniques. If this linear relationship can be determined, predictions can be made regarding achievements. When the predicted differences in achievement between aptitude subgroups vary across treatments, there is an interaction between aptitudes and treatments upon achievement.

Cronbach and Snow (1977) discussed the need to examine affective and cognitive aptitudes in ATI research. They stated:

> Personality as well as ability influences response to a given kind of instruction. Nontest variables (social class, ethnic background, educational history) may serve as proxies for characteristics of the learner that are not directly measurable. Attention ought to go to variables that were neglected in aptitude tests developed under selection modes, since tests that predict outcome under a standard treatment may be differentially predictive of success when more than one treatment is considered. New kinds of aptitude probably need to be detected and measured (p. 6).

Conceptualization of Aptitudes and Treatments

Locus of control in mathematics (LOC-MTH) and general reasoning ability (GRA) were selected as the aptitude variables for this study after close scrutiny of the existing aptitude treatment interaction literature. Cronbach and Snow (1977) suggested the inclusion of general reasoning ability and personality as predictors of differential responses to instructional style. Researchers have utilized LOC-MTH and GRA in a number of the studies that characterized instructional treatments as high structure versus low structure. General reasoning ability has also been studied in the majority of ATI research in mathematics education. The research discussed supports not only the choice of general reasoning ability and locus of control as salient learner aptitudes but also the instructional dichotomy of high structure versus low structure treatment.

Locus of Control

The selection of locus of control in mathematics as an aptitude variable for this ATI study has been supported by Carry (1968), Webb (1971), Eastman (1972), Salhab (1973), DuRapau (1979), Hickey (1980), Friske (1982) and Duran (1985). The research conducted by Rotter (1966) and Lefcourt (1967) have provided the theoretical foundation for locus of control.

Reaction and adaptation to an instructional style involves more than an intellectual component. Certain personality factors may influence the manner in which an instructional situation is perceived by a student. One of the most important of these factors may be locus of control. Extensive reviews of the research on locus of control which have been done by Rotter (1966) and Lefcourt (1967) revealed significant trends concerning human response to learning environments. Lefcourt (1976) summarized the following general definition:

> As a general principle, internal control refers to the perception of positive and/or negative events as being a consequence of one's actions and thereby under personal control; external control refers to the perception of positive and/or negative events as being unrelated to one's own behaviors in certain situations and therefore beyond personal control (p. 207).

According to Rotter, behavior is influenced by an individual's view of the environment, and the role that reinforcement and reward play regarding that behavior. He stated:

> The degree to which the individual perceives that the reward follows from or is contingent upon, his own behavior or attributes versus the degree to which he feels the reward is controlled by forces outside of himself and may occur independently of his own actions may be differently perceived and reacted to by others. The effect of a reinforcement following some behavior on the part of a human subject, in other words, behavior is not a simple stamping-in process but depends upon whether or not the person perceives a causal relationships between his own behavior and the reward (p. 1).

The causal relationship between behavior and the reward is viewed by considering an established set of expectancies indicating the probability of the same reinforcement of a particular behavior occurring in the future. Expectancies are built by encountering similar situations or events. Consequently, expectancies remain in a state of evaluation. The reinforcement received across similar situations play an important part in the strengthening or weakening of these expectancies. According to Rotter, if the same reinforcement is received across similar situations, then a generalized expectancy is established with the cognitive processes.

Rotter's research dealt primarily with the importance of the reinforcement expectancy component of behavior. For this component, Rotter theorized the concept of internal versus external locus of control of reinforcements.

If individuals perceive themselves as being in control of their own reinforcements or rewards, Rotter viewed them as having an internal locus of control. If individuals perceive the environment being strictly in control of reinforcements or rewards, Rotter viewed them as having an external locus of control. The perception of a person being internally versus externally in control of reinforcements influences an individual's expectancy of an event or behavior. Rotter defined locus of control as a generalized expectancy determined by the degree individuals perceive the outcome of the reinforcement as a result of their own actions and aptitudes (internal), or as a result of fate, chance, or external forces around them (external).

In 1954, Rotter began his empirical research on internal versus external locus of control, and developed an instrument, the I-E Scale, to measure the variable. Empirical and correlational studies by Rotter and colleagues tested the validity and reliability of the instrument. A summary of the findings using the I-E Scale are found in Rotter (1966), Lefcourt (1976), and Phares (1976).

Using their research and reviewing pertinent studies, Lefcourt (1976) and Phares (1976) indicated that the construct LOC may be unstable. Individuals that were studied varied according to the environmental situation regarding the degree of internal or external locus of control. Lefcourt (1976) defined LOC as "a circumscribed self-appraisal pertaining to the degree which individuals view themselves as having some causal role in determining specific events" (p. 141). Research has supported a need for specific definitions in particular content areas, accompanied by corresponding assessment instruments to enhance the stability of locus of control.

General Reasoning Ability

The selection of general reasoning ability (GRA) as a predictor of Logo achievement in this study was supported by Carry (1968), Webb (1971), Eastman (1972), Salhab (1973), DuRapau (1979, Hickey (1980), Friske (1982) and Duran (1985). The theories of intelligence of Cattell (1941) and Guilford (1967) provided structures that have helped psychologists explain the facets of human intelligence.

Guilford's Structure of the Intellect model (1967) has been one major theoretical base for conceptualizing general reasoning ability in ATI research. Guilford's model (SI) represents a cross classification of intellectual abilities in intersecting categories. Through extensive factor analysis, he groups these abilities by operation, content, and product.

Guilford places GRA within his SI model in a category labeled cognition of semantic systems. The operation classification contains the abilities that process major kinds of intellectual activities encountered by an individual. This category is divided into subdivisions including: cognition, memory, divergent production, convergent production, and evaluation. Guilford (1971) defines cognition as "awareness, immediate discovery or rediscovery, or recognition of information in various forms: comprehension or understanding" (p. 71).

The product classification contains those abilities that organize the information as an individual processes it. Systems, a category within the product classification, is described by Guilford who stated, "Systems are complexes, patterns, or organizations of interdependent or interacting parts, such as a verbally stated arithmetic problem, an outline, a mathematical equation, or a plan or a program" (p. 64).

The content classification contains those abilities that differed according to the kind of information processed by an individual. The semantic concept is contained in the content category. Guilford maintained the semantic constructs were aspects of abstract intelligence.

This three-way classification model is represented by a three-dimensional cube model. According to his SI model, the factor CMS is the ability to solve problems under restrictions, and was measured primarily by a test of arithmetical reasoning.

ATI research in mathematics education has supported the selection of GRA as a predictor of success in learning mathematics. The Necessary Arithmetic Operations (NAO) test (French, et. al., 1963) has been used to measure GRA. The NAO test has been described by Carry (1983) as:

> A measure of the efficiency with which a subject can make appropriate choice of arithmetic operations necessary to solve exercises in

> English words. In other words, the ability to relate properties of arithmetic operations to their analogues in plain language (p. 418).

Duran (1985) described general reasoning ability measured by the NAO test as the ability to process verbal data that are mathematically related for which the nature of the relationship and its formulation may be called forth into cognitive awareness as the result of the respondent having chosen- as a goal state in mathematics learning- the understanding of such relationships and its formulation in repeated occasions during previous related learning, and to do so efficiently.

Treatments

Ausubel (1968) and Gagne (1970) advocated instruction that sequences key ideas to provide a continuous development from what is already known to the current learning objective. The inferred pattern is hierarchical in that instruction begins with what is known and proceeds with increasing complexity toward the goal. The teacher evaluates each state, provides detailed guidance by breaking the material to be learned into small interdependent parts and anticipates any confusing similarities or differences between new information and that which is already present in the learner's cognitive structure.

In contrast Bruner (1966) advocated an instructional style that organizes the whole of the current learning objective so that structural components become clear in their relationship to what is already known. In this case the instruction emphasizes the structural components and their interrelationships paying much less attention to hierarchical organization, and the teacher guides the student to "discover" the structure for himself. The development of an attitude of inquiry, and confidence in one's own problem solving ability can not be achieved by a mere presentation of ideas, but to Bruner:

> It would seem that an important ingredient is a sense of excitement about discovery--discovery of regularities of previously unrecognized relations and similarities between ideas, with a resulting sense of self-confidence in one's abilities (p. 20).

Cronbach (1965) called for the design of research which will clarify the place and function of discovery learning or inductive teaching.

> We have, on the one hand, the view of education as cultural transmission, which hints strongly that it is the teacher's job to know the answers and to put them before the pupil. on the other, we have the view of education as growth, arguing that the only real and valuable knowledge is that formulated by the pupil out of his own experience (p. 1).

The former style is referred to by Cronbach as didactic teaching and is the model in this study for high structure. Several ATI studies have used the instructional dichotomy high structure versus low structure treatment. Among these are the studies of Peterson (1977) and Winne (1977) from which behavioral specifications for each treatment have been adapted. ATI studies (Salhab, 1973; and Hickey, 1980) have supported the selection of low structure and high structure treatments to interact significantly with the aptitudes general reasoning ability and locus of control.

A low structure treatment utilizes the instructional style in which general objectives are stated, theoretical considerations are discussed, and the learner must sort information to arrive at his/her own meaningful inferences. Low structure treatments support an inductive or discovery approach to teaching. A high structure treatment uses the instructional style in which specific objectives are stated, computational aspects are stressed, and the student is guided to mastery of concepts and skills. Most of the structure for the course material is provided for the student by the teacher. High structure treatments focus the expository or didactic approach to teaching.

Hickey (1980), influenced by the work of Peterson (1977) and Winne (1977), outlined the behavioral criteria for both a low support and high support treatment. These specifications were:

<u>Behavioral Criteria for High Structure</u>

1. Instructor states specific goals/objectives.
2. Instructor gives review of previous day's lesson.
3. Instructor signals for transition. Material broken into small units.
4. Instructor states important points with verbal markers.

5. Instructor gives brief summaries during the lesson.
6. Instructor asks few questions, but uses those few questions and student responses to structure lesson.
7. Instructor waits less than one second after posing question and then begins talking again.
8. Instructor praises correct answer to question.
9. Instructor says "no" to incorrect answer and gives reason why answer is wrong.
10. Instructor prompts incorrect answer by providing a hint about the correct answer.
11. Instructor redirects question to another student when correct answer doesn't follow one or two prompts.
12. Instructor states correct answer.

<u>Behavioral Criteria for Low Structure</u>

1. Instructor states general goals/objectives.
2. Review of previous day's lesson.
3. Few verbal markers of important points.
4. Few signals for transitions. Units flow together.
5. No summaries during lesson.
6. Instructor asks many questions to elicit facts, concepts, principles and opinions but does not specifically use them to tie lesson together.
7. Instructor waits three to five seconds after posing question to allow time for student response.
8. Instructor gives neutral response to correct answer to question, and asks higher order question.

9. Instructor says "no" to incorrect answer.
10. Instructor probes incorrect answer.
11. Instructor redirects question to another student when correct answer doesn't follow one or two probes.
12. Instructor states correct answer.

Supporting ATI Research

In a review of Cronbach and Snow's (1977) treatise on aptitudes and instructional methods, McLeod (1978) asserts, when analyzing interactions:

> They are not easy to find, and they are difficult to replicate, since relevant but uncontrolled conditions always vary somewhat from one study to another... At the moment, it is more appropriate to use ATI research to increase our understanding of the learning process (p. 390).

ATI in Non-Mathematical Areas

Several ATI studies have utilized locus of control with low structure and high structure treatments. Parent, Forward, Canter and Mehling (1975) conducted a study with college students and a two-hour mini-course in computer programming. Students were measured on the I-E locus of control scale (Rotter, 1966), and were assigned to one of two teaching conditions. The high discipline condition adhered to five empirically derived dimensions of perceived high discipline. In the low discipline condition identical materials were used for the content but students were allowed to proceed at their own pace with no externally provided rules. The hypotheses of the study were confirmed. Results showed that students high on internal locus of control performed better under low discipline conditions, while high external control students performed better under high teacher discipline conditions.

Daniels and Stevens (1976) measured 68 college students on locus of control, and within an eight-week course in introductory psychology assigned them to either a high structure teacher lecture section or to a low structure contract grade plan section. The contract grade plan enabled the student to control the outcome, even to the extent of resubmitting work which was not up the minimum standards. If a student fulfilled his contract, he was guaranteed his contracted grade. In the teacher lecture section tests were given at regular intervals and norm referenced grading was used.

It was expected that under the contract plan the achievement motivation of internals would be higher than that of the externals and that just the opposite would be true in the teacher controlled groups. The hypothesis that an interaction would result in terms of differential achievement was confirmed. " A strong disordinal interaction was found, with internals performing better under the contract plan and externals performing better under the teacher controlled method" (p. 103).

Peterson (1977) investigated the interaction of student personality and aptitude with the level of instructional structure received by the ninth graders in social studies. Results revealed a number of significant ATI's. Those most pertinent to this study indicated that highly anxious high ability students respond best to high structure and might tend to go off on tangents under low structure conditions, whereas low anxious high ability students do not need structuring provided by the teacher because of their capacity to choose their own learning cues and to carefully apply their reasoning skills.

ATI in Mathematics Education

Selection of general reasoning ability as the variable with which to seek treatment interaction was motivated by the results which have been obtained in earlier studies. Carry (1968), in studying the relationship between two aptitude variables (general reasoning and spatial visualization) and two treatments (graphical and analytical) in quadratic inequalities, found that although the spatial visualization did not show the expected interaction with the graphical treatment, there was significant interaction between the two instructional treatments and Necessary Arithmetic Operations (NAO) test which was the marker for general reasoning ability (Hickey, 1980).

Webb (1971) made modifications to Carry's (1968) study that included: a redesign of instructional treatments and criterion measures, the inclusion of Melton's (1967) Model to analyze the nature of the instructional treatments in an attempt to explain the interaction effect, and the inclusion of two more predictor instruments: Spatial Visualization II and Mathematics Aptitude Test. Webb found no significant interactions and the two tests of general reasoning (NAO and the Mathematics Aptitude Test) predicted success for both treatments. One of the two tests for spatial visualization predicted success for the graphical treatment and NAO correlated slightly higher with the graphical treatment than with the analytic treatment.

Eastman's research (1972) was the third in the series of studies supervised by Carry. He modified treatments in the Carry and Webb (1971) studies to follow a deductive versus inductive mode. He argued that NAO was deductive and that the marker test used for spatial visualization (the Differential Aptitude Tests-Abstract Reasoning) was highly inductive. Eastman's study tended to confirm Carry's original interaction hypotheses: (a) spatial visualization will predict success in a graphical treatment; (b) general reasoning will predict success in an analytic treatment. His results showed significant interactions in the hypothesized direction. However, whether the interaction was due to the intended variables or to the deductive-inductive structure is not clear.

Salhab (1973) designed an inductive and a deductive treatment on absolute value equations. Using elementary treatment education majors, he predicted an interaction between GRA, spatial visualization, and the instructional treatments. A significant disordinal interaction was found between GRA and the treatments in predicting success on an achievement test on absolute value equations. An individual scoring high on the NAO test performed better under the inductive treatment; and an individual scoring low on the NAO test performed better under the deductive treatment.

DuRapau's (1979) investigation appears to be the most refined of the ATI studies. He conducted a study in which interaction was sought between two cognitive variables, cognition of figural transformations and cognition of figural relations, and two treatments in high school geometry, a transformational approach and a non-transformational approach. As a secondary purpose of the study an investigation was conducted to seek interaction between general reasoning ability and the treatment variables.

His results were positive with significant disordinal interactions found in all cases. The most important finding relative to the present study is that the treatments as designed evolved into one which was fully elaborated (the non-transformational) and the other (the transformational) which left much of the structuring to the learner. A significant disordinal interaction was found between general reasoning ability and this feature of the treatments.

Hickey (1980) investigated a long range test of the aptitude treatment interaction hypothesis in college level mathematics. Other research studies (Seeman and Evans, 1962;

Becker, 1970; Parent et. al., 1975; Daniels and Stevens, 1976; Peterson, 1977; Winne, 1977) provided Hickey (1980) with grounds to support the idea that the personality factor of locus of control interacts with different instructional modes.

Significant evidence of interactions between treatments and aptitude variables in the learning of Finite Mathematics was found. When summarizing her findings Hickey (1980) recommended:

> Internal high ability students should realize maximum achievement in a learning environment in which they are allowed to use their superior reasoning ability and self motivation. On the other hand, external lower ability students should have highest achievement when they are presented material in a way which supplies the structure that carries from one idea to another (p. 97).

McLeod and Adams (1979) conducted a rigorous analysis of the interaction between the ability trait most commonly used in ATI research - general reasoning - and instructional treatments used in traditional school subjects. The purpose of McLeod and Adams' (1979) study was to produce statistical evidence supporting the hypothesis of interaction between general reasoning and field-independence and the two dimensional treatment distinction: level of guidance and inductive-deductive instruction. McLeod and Adam's findings was supporting evidence regrading the existence of ATI effects in the learning of errors of measurement and calculations with approximate data.

Duran (1985) presented an interpretation of a series of ATI findings produced in the area of Mathematics Education. She has used a series of dissertation which were conducted at the University of Texas at Austin under Carry's supervision. One important fact about this series was that the studies had not been conducted in isolation. They represented an evolution of ideas concerning the interactions found and solidly established the existence of ATI. This series of studies has centered on a "main drive"; to determine the nature of discourse that more appropriately embodies a particular idea to be communicated to a particular type of audience.

Summary

The most obvious use of computing in education involves the user as programming (Papert, 1980). An overview of literature concerning Logo has been reviewed. Most of the articles indicated a need for more research in the use of Logo in the school, specially for college students.

In addition, the review of literature included aptitude treatment interaction, locus of control in mathematics, general reasoning ability and two instructional treatments and the relationship that exist between learner characteristics and instructional treatment. Supportive literature was also found for the importance of ATI in the mathematics education.

CHAPTER III

DESIGN AND PROCEDURES

This empirical investigation examined the interaction between two aptitudes and low structure and high structure instructional treatments. The primary purpose of this study was to determine the relationship between the aptitudes general reasoning ability and locus of control in mathematics and the two instructional treatments in a college educational computing course.

Hypotheses

The research reviewed in the previous chapter served as a basis in the formation of the hypotheses concerning the expected relationships among the aptitudes, instructional treatments and the acquisition of knowledge in Logo. They were tested as a part of this ATI investigation.

Hypothesis 1 (H1):

The mean score on the Logo test for the high structure group will not be significantly different from the mean score for the low structure group.

Hypothesis 2 (H2):

There will exist interaction between the high and low structure treatments, general reasoning ability, and locus of control in mathematics. The low structure treatment will result in superior achievement for internal subjects who are high in general reasoning ability. The high structure treatment will result in superior achievement for external subjects with lower general reasoning ability.

Hypothesis 3 (H3):

There will exist an interaction between the high and low structure treatments and locus of control in mathematics. The low structure treatment will result in superior achievement for subjects who are internal. The high structure treatment will result in superior achievement for subjects who are external.

Hypothesis 4 (H4):

There will exist interaction between the high and low structure treatments and general reasoning ability. The low structure treatment will result in superior achievement for subjects high in general reasoning ability. The high structure treatment will result in superior achievement for subjects low in general reasoning ability.

These natural language hypotheses are translated into statistical hypotheses in Chapter IV. The statistical hypotheses were tested using multiple linear regression analysis. An alpha-level of 0.05 was selected on a one-tailed test using the F statistic.

The nature of the general ATI hypothesis makes tests for homogeneity of regression utilizing linear statistical models most appropriate. The approach employed in this study follows that which is suggested by Ward and Jennings (1973).

Population and Sample

The population in this study were the students who were enrolled in Microcomputer Technologies for Education at the college of education at Oklahoma State University during the 1988 Spring Semester. Oklahoma State University is located in Stillwater Oklahoma with an enrollment of approximately 21,000 students. Students who enrolled in the course chose one of eight sections according to the time available which suited their schedules.

Six sections, 120 students, were chosen for the sample to complete the investigation. Three sections were assigned to low structure treatment and three sections were assigned to high structure treatment. Within each section the subjects were then randomly assigned to each treatment group.

Of the 120 participants who were originally registered for the Spring 1988 classes, four did not complete the course, and seven did not take either pretest or posttest, bringing the total number of subjects completing the study to 109. There were a total of fifty nine students in low structure treatment and fifty students in high structure treatment. The course was not limited to college of education students but was open to students in other colleges.

Instructional Treatments

A treatment in instructional research covers any manipulative variable. In this study the treatments were the two styles of instruction received by the subjects and was the independent variable in this study.

The instructional style in which general goals and objectives are stated, theoretical considerations are discussed, and the learner is asked to sort information and make his/her own inferences was defined as low structure treatment. The material presented in class was designed to present the course content using an intuitive concept building process. The instructor asked many questions to elicit facts, principles and opinions but did not specifically use them to tie lesson together.

The instructional style in which specific objectives are stated, computational aspects are stressed, and the student is guided to mastery of concepts and skills was defined as high structure treatment. The material examined in class was designed to present the course content in a complete form, leaving little or no structure for the student to determine.

The low structure sections were not taught purely by the discovery approach nor did the high structure sections provide the entire content structure, but each group was taught with these contrasting philosophies in mind. Both treatments used the same content objectives and concept definitions for all class sessions (see Appendix B). The content objectives were covered at the same rate in each section through weekly coordination by the instructors. Laboratory and outside class assignments were different for each treatment group. The content objectives were divided into weekly lesson. They were:

Week 1 - Introduction to Logo and LogoWriter Turtle Graphics
Week 2 - Defining and Editing LogoWriter Procedures
Week 3 - Writing LogoWriter Super- and Sub- procedures
Week 4 - Writing LogoWriter Structured Programs
Week 5 - Defining Recursive LogoWriter Procedures

A portion of laboratory and outside class assignments for both treatments are found in Appendixes C and D. In an attempt to control a number of extraneous variables, both treatment groups followed these procedures:

1. Both groups were taught on the same brand of computer hardware (Apple IIe with 48k RAM card).
2. Both groups were taught the same Logo concepts.
3. Both groups began with the same two-hour introduction to computers.
4. Both groups spent the same amount of time (2 hours per week for 5 weeks) on Logo concepts.
5. Both groups were taught the same Logo content.

Development of Treatments

The investigator selected Logo as the topic to be studied in the treatments because the language had not been introduced to any of the students; and it could be presented using low and high structure treatments. There were three phases of treatment development. In the first phase, the investigator selected the Logo content to be developed within the instructional treatments. These content objectives were then divided into lessons which were previously discussed.

The investigator outlined the low and high structure specifications for each treatment. These specifications were influenced by studies of Peterson (1977); Winne (1977) and Hickey (1980).

During the second phase, the characterizations for each treatments were incorporated into the content of each lesson as the lecture notes, laboratory objectives and outside assignments were prepared. In the third phase, the investigator revised the treatments according to the inconsistencies found during the pilot study.

Based on the treatment characterizations class examples and presentations for each lesson weekly differed in several ways. A selected portion of the laboratory activities has been provided for both low and high structure treatment (see Appendixes C and D).

Instruments

The aptitudes examined in this study were general reasoning ability (GRA), and locus of control in mathematics (LOC-MTH). Studies by Carry (1968), Webb (1971), Eastman

(1972), Salhab (1973), DuRapau (1979), Hickey (1980), Friske (1982), and Duran (1985) supported the selection of GRA. Since general reasoning ability was established as being fundamental to this study and was expected to interact with the treatment variable, an established measure of this ability was chosen. General reasoning ability was measured by the Necessary Arithmetic Operations (NAO) test (French, Ekstrom, & Price, 1963). This test consists of problems in mathematics. Instead of solving the problems and finding an answer, the student's task was merely to indicate which arithmetic operations were to be used, if they solved the problems. There were 30 problems numbered 1 to 30. This test had two parts each containing 15 multiple choice questions. The student had 5 minutes to complete each part.

Based upon Rotter's (1966) research, locus of control in mathematics (LOC-MTH) was operationally defined as the student's score on Hickey's (1981) Mathematics Attitude scale. Reviews by Lefcourt (1976) and Phares (1976), and research by Daniels and Stevens (1976) and Hickey (1980) supported the selection of locus of control in mathematics. Hickey modeled this Likert-type scale from Rotter's I-E scale to measure locus of control in mathematics. Piloting her instrument with college students, Hickey (1981) reported a reliability coefficient of 0.75. The MA Scale contained 27 items, 16 worded positively, and 11 worded negatively. A copy of each aptitude measure is found in Appendix A.

The Logo Test

The Logo Test was used to assess the subjects Logo ability. Based on the lesson content studied during the investigation, the investigator-constructed a multiple choice Logo achievement test. Two types of items were developed (a) recall and comprehension and (b) synthesis and application to provide opportunities for a subject to display his/her knowledge of Logo. The Logo test was piloted prior to the first session. From a pool of 40 multiple choice items, 33 items were selected. Eleven items were analysis and synthesis items and twelve were recall and comprehension.

An item analysis was conducted to determine which of the items contributed the most information about an examinee’s Logo ability. Item difficulty indicates the percent of some specified group who answer a test item correctly. The higher this percentage is, the easier the item. Difficulty indicates whether an item is easy or hard, not that an item is good or bad. Mean difficulty for this test was 47.17.

Discrimination is an index which indicates the discriminating power of a test item. A discrimination index of 0.70 would result if 85 percent and 15 percent of the students in the upper and lower groups, respectively, responded correctly to a given item. Mean discrimination for this study was 0.29, and the recommended mean discrimination was 0.29. Based on the measurement used in the scoring program, the Logo test's internal reliability coefficient was 0.79; recommended reliability was 0.70. The mean score for this study was 14.15 and the standard deviation was 3.93. The Logo test is found in Appendix A.

Procedure

During the Fall 1987 semester, the researcher contacted university officials and received permission to conduct the study with students who would be enrolled in Microcomputer Technologies for Education in the 1988 Spring semester. Six sections of the course were designated to be used in the study. However, students enrolling in the classes had no knowledge that they would be part of the study. On the first day of classes students were given a verbal description of the nature of the investigation, and were assured the results of the pretests had no effects on their grades. Students in each section were randomly assigned to each treatment.

The investigation was conducted from February 1 1988, to March 7, 1988. The students were tested on the Hickey's (1981) MA scale and the Necessary Arithmetic Operations test during the first 30 minutes of the first class period. The students recorded their responses on a SCAN-TRON form. The scores on these tests were entered into a computer file by a third party so that the instructors would be unaware of the aptitudes of their students. Each student had one SCAN-TRON form containing his/her NAO score on one side and his/her MA score on the other side. The students were told to work on their own, and refrain from talking to other students or asking the teacher for assistance. Another SCAN-TRON form was used for his/her answers to the Logo test. Each score was entered into a computer file and stored by the students' name and ID numbers.

On January 25, 1988, the first orientation session with the two participating instructors was held to distribute aptitude tests and answer sheets. Written directions were given to the instructors, and discussion followed concerning the administration of the aptitude tests. The sections were taught by three graduate students. One instructor taught three sections of low structure; one instructor taught two sections of high structure; and the investigator taught one section of high structure. All the instructors had previously been instructed in LogoWriter. Prior to the beginning of the each weekly class session, the investigator met with instructors to make sure they understood the manner in which the subjects were to be taught for each treatment group.

Each of the class sessions lasted two hours a week. The treatment lessons were distributed at the beginning of class, and collected at the end of class. Students spent approximately 40 minutes in class for lecture and the remaining time was spent in the computer lab on the laboratory assignments. Students were allowed to finish incomplete assignments if any class time remained after completing the designated lesson. The following time table was kept for administering the lessons. A portion of laboratory and outside class assignments for both treatments are found in Appendixes C and D.

Feb. 1-5	Lesson 1
Feb. 8-12	Lesson 2
Feb. 15-19	Lesson 3
Feb. 22-26	Lesson 4
Feb. 29-March 7	Lesson 5

The Logo test was administered at the end of week six. The students were not given a time limit, but most completed the test within one hour. The students recorded their responses to the Logo test on SCAN-TRON answer sheets.

Pilot Study

A sample of 40 students enrolled in Microcomputer Technologies for Education prior to the investigation was obtained for the pilot study. In the Spring 1988, the researcher taught both low and high structure classes for five weeks. The NAO test and MA scale instruments were administered in two classes by the investigator during the first week of January, 1988. The students used a SCAN-TRON answer sheet for both tests. Using the statistical program available through the Oklahoma State University, tests were scored and analyzed. A reliability coefficient of 0.80 was found for the NAO test and a reliability coefficient of 0.82 was found for MA scale.

The Logo test was administered to both treatment groups. The questions selected were based on their consistency with assignment problems found in the treatment lessons. The investigator constructed four answer selections for each item.

CHAPTER IV

DATA ANALYSIS AND INTERACTION OF RESULTS

The primary purpose of this study was to investigate the relationship between the aptitudes general reasoning ability and locus of control in mathematics and two instructional treatments for developing Logo concepts in college level students. A secondary purpose of this study was to provide information to assist in planning and adapting instruction in Logo to the individual differences of college students enrolled in an introductory computing course.

The data from this study were analyzed using SYSTAT (Wilkinson, 1986) through the computation center facilities of the Oklahoma State University at Stillwater. This chapter presents the findings on each of the four hypotheses investigated as a part of this aptitude treatment interaction study.

Hypotheses

Chapter III contained the hypotheses stated in natural language. In this chapter they are restated in null form for statistical analysis. The hypotheses of this study were tested using multiple linear regression techniques described by Ward and Jennings (1973).

Hypothesis 1 (H1):

Null form: The expected score on the Logo test of a student in the low structure group is equal to the corresponding expected score for a student in the high structure group.

Alternative: The expected score on the Logo test of a student in the low structure group is not equal to the corresponding expected score for a student in the high structure group.

Hypothesis 2 (H2):

Null form: The expected difference in scores on the Logo test per unit difference in the optimal linear combination of scores on the Mathematics Attitude Scale (MA scale) and the Necessary Arithmetic Operation test (NAO test) for the low structure group is equal to the corresponding expected difference for the high structure group.

Alternative: The expected difference in scores on the Logo test per unit difference in the optimal linear combination of scores on the MA scale and NAO test for the low structure group is higher than the corresponding expected difference for the high structure group.

Hypothesis 3 (H3):

Null form: The expected difference in scores on the Logo test per unit difference in the MA scale test for the low structure group is equal to the corresponding expected difference for the high structure group.

Alternative: The expected difference in scores on the Logo test per unit difference in the MA scale for the low structure group greater than the corresponding expected difference for the high structure group.

Hypothesis 4 (H4):

Null form: The expected difference in scores on the Logo test per unit difference in the NAO test for the low structure group is equal to the corresponding expected difference for the high structure group.

Alternative: The expected difference in scores on the Logo test per unit difference in the NAO test for the Low structure group is greater than the corresponding expected difference for the high structure group.

Models for Hypotheses

Ward and Jennings (1973) have indicated that models are simply ways of formalizing hypotheses. Multiple regression models have allowed the investigator to predict, explain, and analyze the hypotheses in a precise manner. Linear regression analysis techniques, make it possible to determine "good" expected values from a two underlying assumptions. They are: (a) the criterion scores for the sample must possess a normal distribution; and (b) the model must be "true". Ward and Jennings (1973) stated,

> A model is true if the expected values can be expressed as a linear combination of observable values and unknown parameters in the way described by the model (p. 291).

According to Ward and Jennings, if the assumptions are not violated, then the model produces "good" (unbiased, efficient, and consistent) estimates of the expected values.

Based on the analysis, the criterion scores from the Logo test possessed a representative normal distribution. Thus the model for Hypothesis 1 was known to be true by Ward and Jennings' definition. Based on the review of literature the models formulated for Hypothesis 2-4 were assumed to be true. The model assumed a linear relationship between the scores of the aptitudes and the scores of the Logo test for each treatment group.

Descriptive Statistics for Aptitude Measures and Logo Test

The means and standard deviations of all tests administered to the two treatment groups are listed in Table I. The same statistics for the entire sample are listed in Table II.

TABLE I

MEANS AND STANDARD DEVIATIONS OF TEST MEASURES FOR BOTH TREATMENT GROUPS

Test	Maximum Possible Score	Treatment Group High Structure n=51		Low Structure n=58	
		Mean	S.D.	Mean	S.D.
Mathematics Attitude	135	73.98	15.52	71.43	15.04
Necessary Arithmetic Operations	30	15.53	4.11	15.07	4.20
Logo Test	33	24.31	4.84	25.03	3.86

TABLE II

MEANS AND STANDARD DEVIATIONS OF TEST MEASURE FOR THE ENTIRE SAMPLE

Test	Maximum Possible Score	Sample n=109	
		Mean	S.D.
Mathematics Attitude	130	72.62	15.25
Necessary Arithmetic Operations	30	15.28	4.14
Logo Test	33	24.70	4.34

Reliability Coefficients

Cronbach's alpha internal consistency reliability coefficients were computed for the entire sample on each measure used in this study. The coefficients are reported in Table III.

TABLE III

RELIABILITY COEFFICIENTS OF TEST MEASURES

Test	Total Sample n = 109
Mathematics Attitude	0.82
Necessary Arithmetic Operations	0.80
Logo Test	0.78

The Mathematics Attitude scale, yielded a high degree of internal consistency coefficient of 0.82. The Necessary Arithmetic Operations test yielded a reliability coefficient of 0.80. A Logo achievement test was used as the dependent measure in tests of all four hypotheses. The reliability coefficient for this test was 0.78.

Correlation Coefficients

Pearson Product Correlation Coefficients for the test measures for each treatment group are presented in Table IV, and for the entire sample in Table V.

TABLE IV

WITHIN GROUP CORRELATION COEFFICIENTS FOR TEST MEASURES (PEARSON CORRELATION MATRIX)

Test	1	2	3
High Structure (n = 51)			
1. Necessary Arithmetic Operations	1.00	-0.36	0.45
2. Mathematics Attitude		1.00	-0.32
3. Logo Test			1.00
Low Structure (n = 58)			
1. Necessary Arithmetic Operations	1.00	-0.21	0.28
2. Mathematics Attitude		1.00	-0.15
3. Logo Test			1.00

TABLE V

TOTAL SAMPLE CORRELATION COEFFICIENTS FOR TEST MEASURES (PEARSON CORRELATION MATRIX)

n = 109

Test	1	2	3
1. Necessary Arithmetic Operations	1.00	-0.28	0.36
2. Mathematics Attitude		1.00	-0.24
3. Logo Test			1.00

The correlations between the Necessary Arithmetic Operations test, Mathematics Attitude scale and the Logo test display the directions indicated by the hypothesized relationships. Both the general reasoning ability measure and the locus of control in mathematics measure were negatively correlated to Logo test for each treatment group. None of the aptitudes show a strong relationship to the dependent measure.

Relative Effects of Treatments

Analysis for Hypothesis 1

Hypothesis 1, a test for equal means on the Logo test for both the high and low structure treatment groups was not rejected. As can be seen in Table I, the high structure mean score is 24.31 and low structure mean score is 25.03, the actual difference between the means for the two treatment groups is 0.72. Based on the analysis, the null form of H1 was not rejected. This fact along with the data in Table I are strong indications that the treatments were not differentially effective on Logo achievement and Hypothesis 1 is supported.

TABLE VI

TEST FOR EQUAL LOGO TEST MEANS-LOW STRUCTURE GROUP VS. HIGH STRUCTURE GROUP

	SS	df	MS	F	P
Treatment Means	14.1	1	14.1	.75	.39
Error	2018.92	107	18.87		

Regression Analysis for Interaction Hypotheses

Three ATI hypotheses were tested using multiple linear regression techniques. H2 examined the interaction between the aptitudes general reasoning ability locus of control in mathematics two treatments and the Logo Achievement test. H3, and H4 tested the relationship between each individual aptitude with the same instructional treatments.

Analysis for Hypothesis 2

The Logo test scores were regressed on the predictor scores from the NAO test and the MA scale. The results of the analysis are presented in Tables VII and VIII. Table VII contains the data describing the equation coefficients for the regression plane for both treatment groups. Table VIII displays the results of the test for a zero weight on the interaction terms presented in Table VII. A significant interaction is indicated by the results. Thus, the null form of H2, parallelism between regression planes, was rejected.

TABLE VII

REGRESSION OF LOGO TEST SCORES ONTO PREDICTOR SCORES FROM THE NAO TEST AND MA SCALE

	Predictors					
	Constant	Sec	Aptitude		Interaction	
			NAO	MA	Sec*NAO	Sec*MA
Raw Weight	19.45	1.93	.67	-.086	-.22	.03
Standard Weight	-	.22	.64	-.30	-.50	.29

R*R = .174	Multiple R = .417	Standard Error of Estimate = 4.04

TABLE VIII

H2 - TEST FOR ZERO WEIGHT ON INTERACTION TERMS NECESSARY ARITHMETIC OPERATIONS AND MATHEMATICS ATTITUDE

Source	SS	df	MS	F	P
Interaction	303.65	2	151.82	9.31	.001
Error	1729.36	106	16.32		

To obtain more information concerning the analysis reported for H2, the equations for the regression planes for each treatment are given as follows:

If Y is the predicted Logo test score, then

Low Structure: $Y = 19.45 - 0.086\ (MA) + 0.671\ (NAO)$

High Structure: $Y = 21.38 - 0.056\ (MA) + 0.452\ (NAO)$

These regression planes intersect within the measurable range of the aptitude.

To aid in clarifying the analysis of this hypothesis, cross sections of the planes were examined to determine the regression lines for the treatment groups relative each aptitude variable.

Using the mean for the NAO test, the equations representing the cross sections relative to locus of control in mathematics were:

Low Structure: $Y = 29.70 - 0.086\ (MA)$

High Structure: $Y = 28.28 - 0.056\ (MA)$

These lines intersect at an MA value of 47.3 and a Y value of 25.63 . The graphs are shown in Figure 1.

Using mean for the MA test, equations representing the cross sections relative to general reasoning ability were:

Low Structure: $Y = 13.2 + 0.671\ (NAO)$

High Structure: $Y = 17.31 + 0.452\ (NAO)$

The intersection of these two lines occurs at an NAO value of 18.77 and Y value of 25.78. The graphs are shown in Figure 2.

The graphs of the cross sections support that students who are low in locus of control in mathematics and high in general reasoning ability perform better on the Logo test under the low structure treatment. Students who are high in locus of control in mathematics and low in general reasoning ability perform better on the Logo test under the high structure treatment. These observations lend further evidence to the directional claims made in Hypothesis 2.

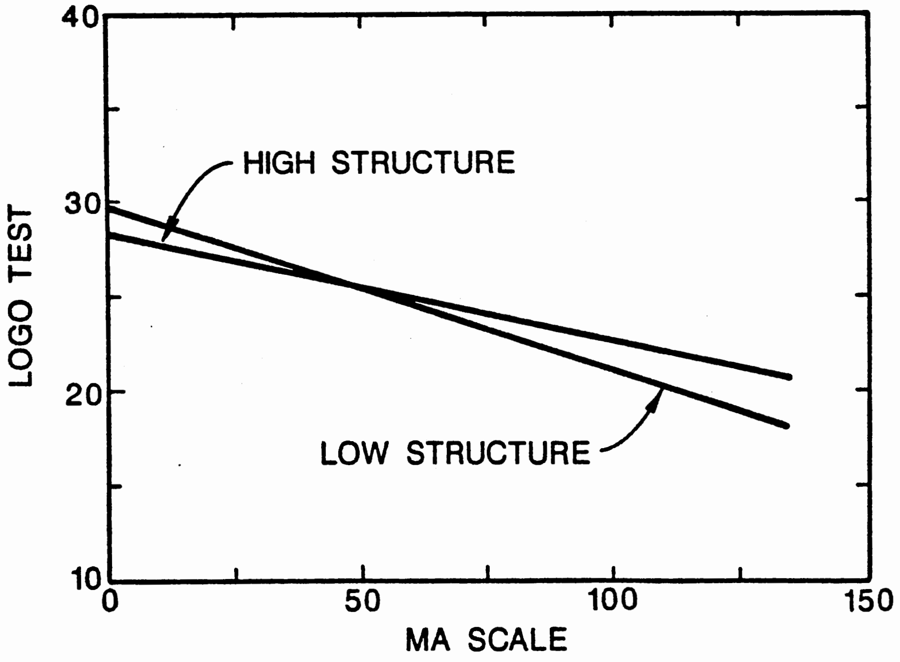

Figure 1. The Regression Lines Representing the Cross Sections for the MA Scale Using NAO Test Mean, with the Logo Test as Criterion

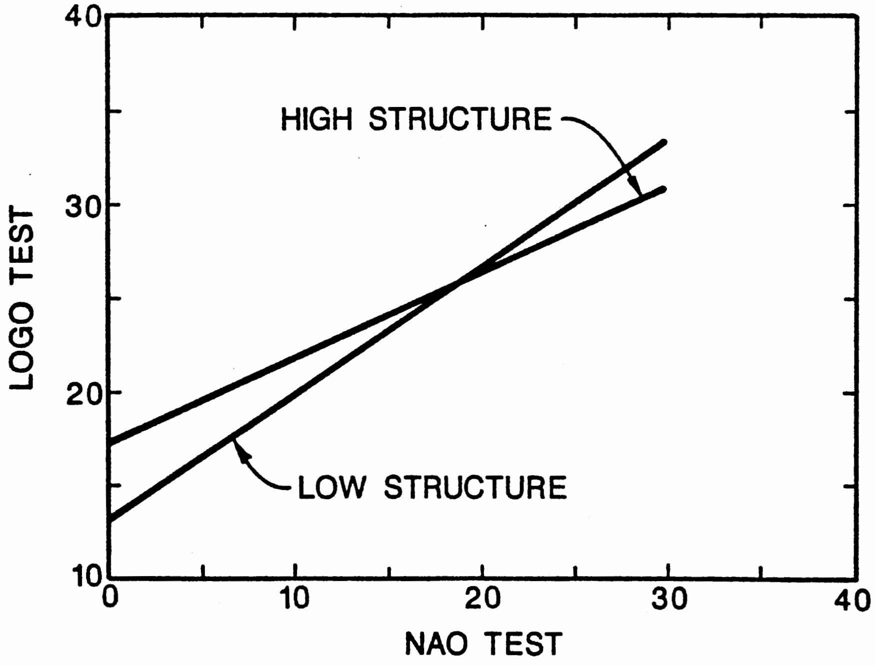

Figure 2. The Regression Lines Representing the Cross Sections for the NAO Test Using MA Scale Mean, with the Logo Test as Criterion

Analysis of Hypothesis 3

The Logo Test scores were regressed on the predictor scores for the Mathematics Attitude Scale to test this hypothesis. The results of the analysis are presented in Tables IX and X. Table IX contains the data describing the equation coefficients for the regression line for both treatment groups. Table X displays the results of the test for a zero weight on the interaction terms presented in Table IX. A significant interaction is indicated by the results. Thus, the null form of H3, parallelism between regression lines, was rejected.

TABLE IX

REGRESSION OF LOGO TEST SCORES ONTO PREDICTOR SCORES FROM THE MATHEMATICS ATTITUDE SCALE

	Predictors			
	Constant	Sec	Aptitude MA	Interaction Sec*MA
Raw Weight	35.44	-3.81	-.16	.06
Standard Weight	-	-.44	-.56	.58

R*R = .075 Multiple R = .273 Standard Error of Estimate = 4.23

TABLE X

H3 - TEST FOR ZERO WEIGHT ON INTERACTION TERM MATHEMATICS ATTITUDE SCALE

Source	SS	df	MS	F	P
Interaction	121.10	1	121.10	6.78	.01
Error	1911.91	107	17.87		

To obtain more information concerning the analysis reported for H3, the equations for the regression lines for each treatment are given as follows:

If Y is the predicted Logo test score, then

Low Structure: Y = 35.44 - 0.159 (MA)

High Structure: Y = 31.63 - 0.099 (MA)

The graph of the lines of the aptitude measure (MA) has been pictured in Figure 3. The two lines intersect at an MA value of 63.5 and a Y value of 25.35.

The graphs provide additional support that students who are low in locus of control in mathematics perform better on the Logo test under the low structure treatment. Students who are high in locus of control in mathematics perform better on the Logo test under the high structure treatment. These observations lend further evidence to the directional claims made in Hypothesis 3.

Analysis of Hypothesis 4

The Logo Test scores were regressed on the predictor scores for the Necessary Arithmetic Operations test to test this hypothesis. The results of the analysis are presented in Tables XI and XII. Table XI contains the data describing the equation coefficients for the regression line for both treatment groups. Table XII displays the results of the test for a zero weight on the interaction terms presented in Table XI. A significant interaction is indicated by the results. Thus, the null form of H4, parallelism between regression lines, was rejected.

TABLE XI

REGRESSION OF LOGO TEST SCORES ONTO PREDICTOR SCORES FROM THE MATHEMATICS ATTITUDE SCALE

	Predictors			
	Constant	Sec	Aptitude NAO	Interaction Sec*NAO
Raw Weight	10.98	5.12	.80	-.28
Standard Weight	-	.59	.77	-.63
R*R = .154	Multiple R = .393		Standard Error of Estimate = 4.05	

TABLE XII

H4 - TEST FOR ZERO WEIGHT ON INTERACTION TERM NECESSARY ARITHMETIC OPERATIONS TEST

Source	SS	df	MS	F	P
Interaction	257.34	1	257.34	15.51	.001
Error	1775.67	107	16.60		

To obtain more information concerning the analysis reported for H4, the equations for the regression lines for each treatment are given as follows:

If Y is the predicted criterion score, then

Low Structure: $Y = 10.98 + 0.804\ (NAO)$

High Structure: $Y = 16.10 + 0.528\ (NAO)$

The graph of the lines of the aptitude measure (NAO) has been pictured in Figure 4. The two lines intersect at an NAO value of 18.55 and a Y value of 25.9. The graphs provide additional support that students who are low in general reasoning ability perform better on the Logo test under the high structure treatment. Students who are high in general reasoning ability perform better on the Logo test under the low structure treatment. These observations lend further evidence to the directional claims made in Hypothesis 4.

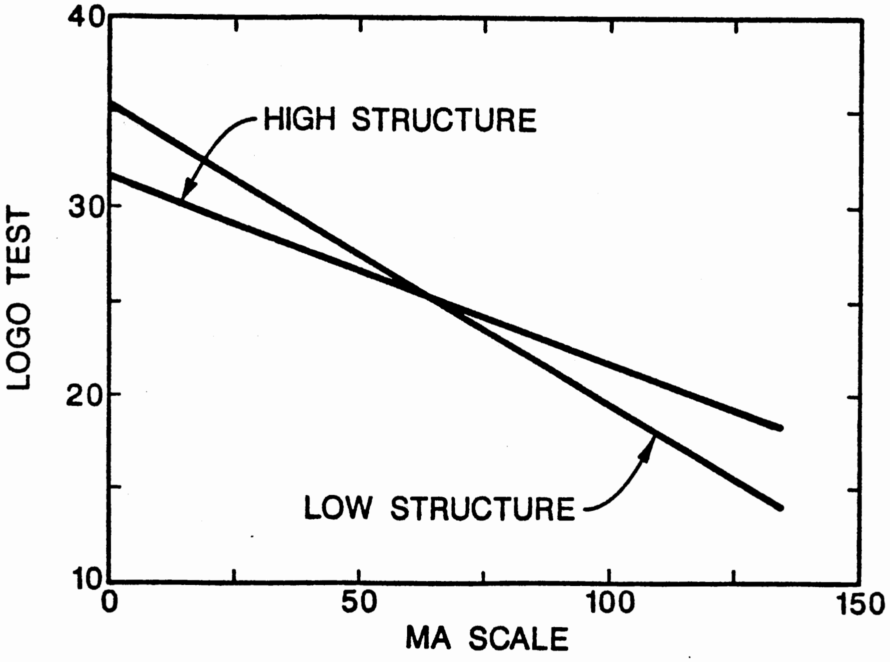

Figure 3. Regression Lines for the MA Scale with the Logo Test as Criterion

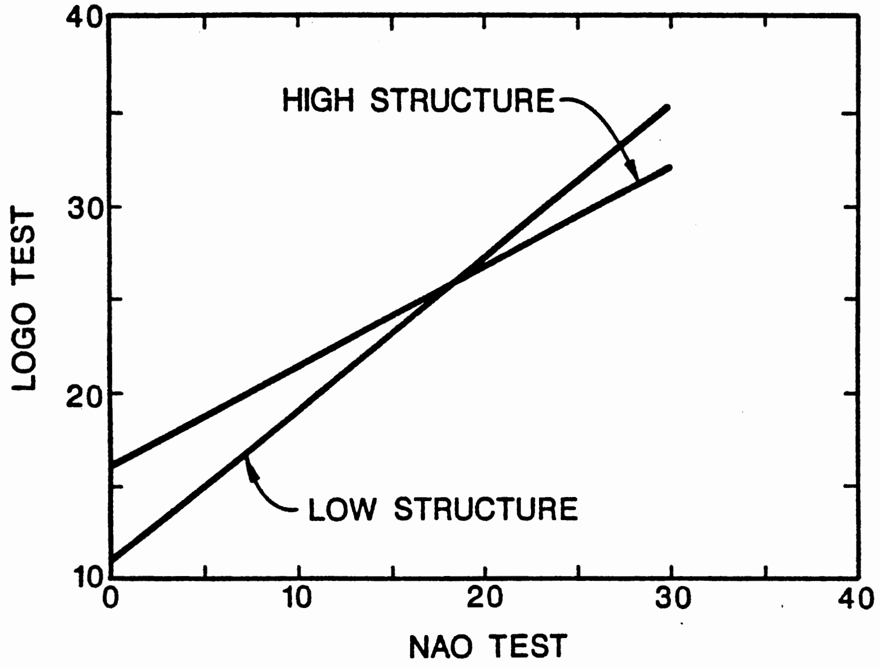

Figure 4. Regression Lines for the NAO Test with the Logo Test as Criterion

Summary

Descriptive statistics, correlational coefficients, and reliability coefficients of the test measures were reported. Hypothesis 1, a test for equal means on the Logo test for the high structure and low structure treatment groups was not rejected. This result confirmed the existence of an disordinal interaction between low and high structure treatments on the Logo test.

Hypotheses 2, 3 and 4 tested for significant interactions between low and high structure treatments on the Logo test with aptitudes general reasoning ability and locus of control in mathematics. All hypotheses yielded significant differences ($\alpha < .05$). Equations of the regression planes for each treatment group were reported for the analysis of H2. In addition, equations of regression lines for each treatment group with corresponding figures were reported for the analysis of H3 and H4.

The findings support that students who are low in locus of control in mathematics and high in general reasoning ability perform better on the Logo test under the low structure treatment. Students who are high in locus of control in mathematics and low in general reasoning ability perform better on the Logo test under the high structure treatment.

CHAPTER V

SUMMARY, DISCUSSION, LIMITATIONS, IMPLICATIONS, RECOMMENDATIONS AND CONCLUDING STATEMENT

Summary of Research Methods

This study was an empirical investigation of the relationship between the aptitudes general reasoning ability and locus of control in mathematics and two contrasting treatments for developing Logo concepts in an introductory college computing course. An Interaction was sought between learner characteristics and instructional treatments and their effects on Logo achievement. Previous research in the mathematics education had confirmed the existence of ATI using these aptitudes, and this study, conducted in the Spring semester of 1988, was designed to clarify the nature of these interactions as they related to achievement in Logo.

The instructional treatments were designated as high structure, in which most of the course structure was provided for the student by the teacher, and low structure, in which most of the structure was left for the student to develop from their assignments through discovery approach.

One hundred nine students enrolled in six sections of an introductory educational computing course participated in Three sections were assigned to low structure treatment and three sections were assigned to high structure treatment. Within each section the subjects were then randomly assigned to each treatment group.

The sections were taught by three graduate students. One instructor taught three sections of low structure; one instructor taught two sections of high structure; and the investigator taught one section of high structure. The subjects were pretested on the Mathematics Attitude scale (Hickey, 1981) and the Necessary Arithmetic Operations test (French, et. al., 1963) at the beginning of the study. Each of the treatment sessions lasted two hours a week, for five weeks. The investigator developed a 33 item multiple choice Logo achievement test that was administered at the end of week six. The Logo test was used as the dependent measure in testing the four hypotheses.

Discussion of Results

Multiple linear regression techniques were used to analyze the data collected as a part of this aptitude treatment interaction study. An alpha-level of 0.05 was selected as the criteria for statistical decision. In this section the hypotheses have been restated and the conclusions drawn from the data analysis are discussed.

Hypothesis 1. The mean score on the Logo test for the high structure treatment will not be significantly different from the mean score for the low structure treatment.

Descriptive and inferential statistics revealed no reasons to reject the null form of Hypothesis 1. There was no evidence that the treatments were differentially effective in facilitating learning in Logo. The high structure mean score was 24.31 and low structure mean score was 25.03, the actual difference between the means for the two treatment groups is 0.72. Therefore, it was concluded that the groups were not significantly different in the characteristics which served as predictor variables in this investigations. In addition any interaction found would thus be disordinal.

Hypothesis 2. There will exist interaction between the high and low structure treatments, general reasoning ability, and locus of control in mathematics. The low structure treatment will result in superior achievement for internal subjects who are high in general reasoning ability. The high structure treatment will result in superior achievement for external subjects with lower general reasoning ability.

The Necessary Arithmetic Operations test (French, et. al., 1963) and Hickey's Mathematics Attitude scale (1981) were used to measure the aptitudes general reasoning ability and locus of control in mathematics, respectively. Previous research justified the use of NAO (Carry, 1968; Webb, 1971; Eastman, 1972; and DuRapau, 1979; Hickey, 1980; Friske, 1982 and Duran, 1985) and the Hickey's Mathematics Attitude Scale for this purpose. The statistical analysis of results indicated significance differences ($\alpha < .05$), thus, the null hypothesis was rejected.

> Hypothesis 3. There will exist an interaction between the high and low structure treatments and locus of control in mathematics. The low structure treatment will result in superior achievement for subjects who are internal. The high structure treatment will result in superior achievement for subjects who are external.

The aptitude which was the predictor variable for this hypothesis was locus of control in mathematics measured by Hickey's Mathematics Attitude scale. The results for Hypothesis 3 yielded statistically significant interactions. The line for the low structure group had the greater slope, supporting the prediction of Hypothesis 3.

> Hypothesis 4. there will exist interaction between the high and low structure treatments and general reasoning ability. The low structure treatment will result in superior achievement for subjects who are high in general reasoning ability. The high structure treatment will result in superior achievement for subject who are low in general reasoning ability.

The aptitude which was the predictor variable for this hypothesis was general reasoning ability measured by scores on the NAO test. The results for Hypothesis 4 yielded statistically significant interactions. The line for the low structure group had the greater slope, supporting the prediction of Hypothesis 4.

Limitations of the Study

Any evaluation of the results of this study should consider the following limitations.

1. The subjects in this investigation were all students enrolled in Microcomputer Technologies for Education in a Midwestern University. The population from which the sample was drawn is not necessarily typical of campuses in this geographical region and this should be borne in mind when generalizing results to other populations.

2. Although conscientious effort was made by both instructors and investigator to stay within the strict definition of each treatment, it is obvious that this could not absolutely be assured.

Implications of the Study

The outcomes of this study have several implications for education. There is strong evidence that the mean performance of students on the Logo test is not significantly affected by the contrasting instructional treatments used, but students at the extremes of the aptitude scales respond favorably to instruction suited to their characteristics. This knowledge can be expected to assist in planning and in adapting Logo instruction that focuses on the aptitudes and needs of college students enrolled in an introductory educational computing course. In particular, students high in general reasoning ability and low in locus of control in mathematics, should realize maximum achievement in a low structured learning environment in which they are allowed to use their reasoning ability and self motivation. On the other hand, students low in general reasoning ability and high in locus of control in mathematics, should have highest achievement when Logo concepts are presented in a way which supplies the structure that carries them smoothly from one idea to another.

Ultimately these introductory experiences for pre-service educators can enhance building positive attitudes with appropriate programming experiences that can be applied in other related educational computing.

Recommendations and Concluding Statement

For the future studies in this area of research the following recommendations are suggested. Although many of the variables were controlled, there were others beyond the investigator's control. In this study too much time was needed to familiarize the students to Logo and teach them programming techniques. Therefore, it is recommended that the study be replicated with a larger sample over a longer treatment period of time.

It is also recommended that other ATI studies be conducted that replicate this investigation using programming languages other than Logo appropriate for pre-service teachers.

Any contribution made by this study is due to the previous studies in mathematics education which meticulously laid the groundwork by defining the important variables. Replications of this study should confirm the findings presented, thus extending and clarifying the nature of ATI in an educational computing environment.

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APPENDIXES

APPENDIX A

APTITUDE MEASURES AND LOGO TEST

(HICKEY'S LOCUS OF CONTROL INSTRUMENT FOR MATHEMATICS)

DIRECTIONS

MATHEMATICS ATTITUDE SCALE

On the following pages is a series of statements. There are no correct answers for these statements. They have been set up in a way which permits you to indicate the extent to which you agree or disagree with the ideas expressed.

Statement No.1	No matter how hard I study I can't do as well as I should in math.

As you read the statement, you will know whether you agree or disagree. If you strongly agree, blacken A opposite Number 1 on your answer sheet. If you agree but with reservations, that is, you do not fully agree, blacken B. If you do disagree with the idea, indicate the extent to which you disagree by blackening D for disagree or E if you strongly disagree. But if you neither agree nor disagree, that is, you are not certain, blacken C for undecided. Also, if you cannot answer a question, blacken C. Now mark your answer sheet. Do the same for statement No. 2.

Statement No.2	What makes math fun to learn is that so many ideas fit together.

Do not spend much time with any statement, but be sure to answer every statement. Work fast but carefully.

There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help you make a choice. Do not mark on the booklet.

THIS INVENTORY IS BEING USED FOR DATA COLLECTION ONLY AND NO ONE WILL KNOW WHAT YOUR RESPONSES ARE.

MATHEMATICS ATTITUDE SCALE

DIRECTIONS

On the following pages is a series of statements. There are no correct answers for these statements. They have been set up in a way which permits you to indicate the extent to which you agree or disagree with the ideas expressed. For example Statement No. 1 reads:

1. No matter how hard I study I can't do as well as I should in math.

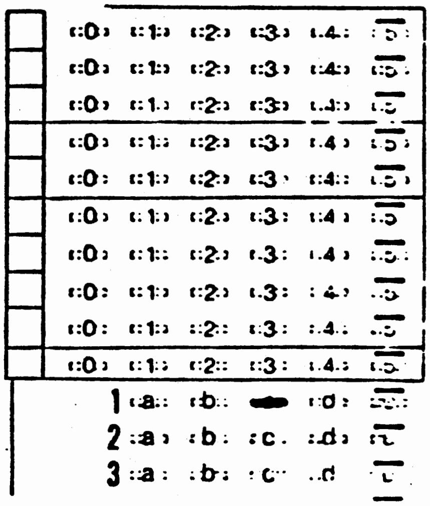
On your answer sheet if you strongly agree
blacken a opposite No. 1;

if you agree but with reservations blacken b;

if you disagree with the idea blacken d;

if you strongly disagree with the idea
blacken e;

and if you are not certain, undecided, or
cannot answer the question blacken c.



The example has been marked c for not certain. Now mark your response on your answer sheet for No. 1. If you have any questions ask the teacher now.

Do not spend much time with any statement, but be sure to answer every statement. Work fast but carefully.

There are no "right" or "wrong" answers. The only correct responses are those that are true for you. Whenever possible, let the things that have happened to you help you make a choice. Do not mark on the test.

THIS INVENTORY IS BEING USED FOR DATA COLLECTION ONLY AND NO ONE WILL KNOW WHAT YOU RESPONSES ARE.

1. No matter how hard I study I can't do as well as I should in math.
2. What makes math fun to learn is that so many ideas fit together.
3. If I have trouble understanding something in math class it is usually because I didn't listen carefully.
4. If I find it hard to work math problems it is usually because I didn't study well enough before I tried them.
5. There is no connection between how hard I study mathematics and the grades I make.
6. There are lots of math problems I could never work no matter how hard I tried.
7. Math is a bunch of unrelated facts I always have to memorize.
8. After taking a math test I usually know how well I've done.
9. I can work most of my math assignments after listening carefully in class.
10. I believe I can work almost any math problem by working hard enough.
11. Now knowing how to begin a math problem is always happening to me.
12. If I find it hard to work math problems it is usually because the problems are too hard.
13. About the only time I do really well on a math test is when the test is easy.
14. My teachers often give math problems that are unreasonably hard.
15. There is a direct connection between how hard I study math and the grades I get.
16. If I work hard enough I can usually make the grade I want in a math class.
17. Many times math exam questions tend to be so unrelated to course work that studying is really useless.
18. I really prefer to work math problems before I look at the answers.

19. When I learn something quickly in math class it is usually because I paid close attention.

20. If I encounter an especially difficult math problem my first impulse is to ask for help.

21. I usually know how to start working my math assignments.

22. If I encounter a math problem that I can't work quickly I don't want anyone telling me how to work it until I've tried several times to do it myself.

23. If a student is really well prepared there is rarely if ever any such thing as an unfair math test.

24. When a question is left unanswered in a math class, I usually think about it afterward.

25. The challenge of math problems does not appeal to me.*

26. Once I start trying to work on a math puzzle, I think about it off and on until I get the solution.

27. If I have trouble understanding something in mathe class it is usually because the teacher didn't explain it very well.

* This item is form Effectance Motivation in Mathematics Scale, FennemaSherman Mathematics Attitudes Scales.

NECESSARY ARITHMETIC OPERATIONS TEST -- R-4

DO NOT make any marks in this booklet
Mark your answers on the separate answer sheet

This test consists of problems in mathematics. However, instead of solving the problems and finding an answer, your task will be mere to indicate which arithmetic operations could be used, if you solved the problems. Mark on the answer card the option that you select. There are 30 problems numbered 1 to 30. Mark the answers on the answer card beginning with number 1.

Example A

If a man earns $2.75 an hour, how many hours should he work each day in order to make an average of $22.50 per day?

a. subtract
b. divide
c. add
d. multiply

In order to solve the problem you should divide $22.50 by $2.75; therefore, you should select 'b' and mark '2' on the answer card.

Example B

Desks priced at $40 each are being sold in lots of 4 at 85% of the original price. How much would 4 desks cost?

a. divide and add
b. multiply and multiply
c. subtract and divide
d. multiply and divide

One way to solve the problem would be to multiply $40 by .85 and then multiply this product by 4; therefore, you should have selected ' and marked '2' on the answer card. (Although some problems may be solved in more than one way, as with Example B, only the operations for one of these ways will be given among the options.)

When 2 operations are given, they are always given in the order in which they should be performed.

Your score on this test will be the number marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have 5 minutes for each of the 2 parts of this test. Each part has 3 pages. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.

Part 1 (5 minutes)

1. There are 4 quarts in a gallon and 4 cups in a quart. How many cups are there in a gallon?

   a. add
   b. subtract
   c. multiply
   d. divide

2. An electric planer is set to remove .02 of an inch each tim a piece of wood is passed through it. If a board is put through 7 times, how much wood will have been removed?

   a. multiply
   b. subtract
   c. divide
   d. add

3. There are 54 children at a small summer camp. If there are 33 boys attending the camp, how many campers are girls?

   a. add
   b. multiply
   c. subtract
   d. divide

4. A man wants to seed a lawn around his new home. His lot is 120 feet by 90 feet (10,800 sq. feet). His house is centere on the lot and occupies 2,785 square feet. How many square feet of ground may be put into lawn?

   a. add
   b. divide
   c. multiply
   d. subtract

5. A wholesale meat dealer sells sirloin steak for $.72 per pound and chuck steak for $.31 per pound. One day he sold 79 pounds of each. How much money was taken in?

   a. add and divide
   b. add and multiply
   c. multiply and subtract
   d. divide and divide

GO ON TO THE NEXT PAGE

Part 1 (continued)

6. A cyclist in an international bicycle race has covered an average of 9 miles every 20 minutes. If he can maintain the same average speed, how long will it take him to cycle the remaining 84 miles of the race?

   a. divide and multiply
   b. subtract and divide
   c. add and subtract
   d. divide and add

7. A grocer sells oranges for 59 cents a dozen. The oranges cc him 33 cents a dozen. How much profit is there on each orange?

   a. subtract and multiply
   b. divide and subtract
   c. add and divide
   d. subtract and divide

8. A boy works in a store after school for a total of 10 hours week. He also works 8 hours on Saturdays. How much is he being paid per hour, if he makes $20.70 per week?

   a. multiply and subtract
   b. add and divide
   c. divide and subtract
   d. add and multiply

9. A housewife took a job which pays $65.00 per week. After withholding and other taxes she is left with 76% of her salary, and each week she spends a total of $6.00 on lunches and bus fares. How much does her job increase the family income?

   a. divide and subtract
   b. subtract and multiply
   c. add and divide
   d. multiply and subtract

10. A rectangular underground reservoir is 15 feet deep and contains 2,000,000 gallons of water, when it is full. Sprin rains filled the reservoir, but a summer drought caused the water level to drop 8 feet. Approximately how many gallons of water were consumed during the drought?

   a. subtract and divide
   b. add and subtract
   c. divide and multiply
   d. subtract and multiply

GO ON TO THE NEXT PAGE

Part 1 (continued)

11. A certain cut of beef costs $.75 per pound. How much beef could a housewife serve to each of 5 people, if she could only afford to spend $2.00 for the beef?

    a. divide and divide
    b. multiply and add
    c. subtract and multiply
    d. divide and multiply

12. A coat marked $40 was sold for $29.95 during a sale. What the per cent reduction?

    a. divide and add
    b. subtract and divide
    c. multiply and subtract
    d. add and divide

13. At the beginning of a month, a car rental organization rente 37 cars. During the month, 32 of these cars were returned. If, at the end of the month, 43 of their cars were being rented, how many new rentals had been made?

    a. subtract and divide
    b. subtract and subtract
    c. add and subtract
    d. multiply and add

14. A corporation doubled its assets by selling 1,000 shares of stock at $75 per share. What were the corporation's total assets after the stock had been sold?

    a. multiply and divide
    b. add and multiply
    c. add and subtract
    d. multiply and multiply

15. A certain housewife generally squeezes 1 1/2 oranges for a glass of orange juice. The average cost of the oranges she bought during one year was $.04 per orange. Approximately how much did it cost the family for the 827 glasses of juice that they drank during the year?

    a. multiply and subtract
    b. add and divide
    c. multiply and multiply
    d. divide and multiply

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO

STOP

Part 2 (5 minutes)

16. If chocolate bars are sold by the dozen at a cost of 49 cents, how much does each bar cost?

    a. multiply
    b. divide
    c. add
    d. subtract

17. If a woman can weave a small rug in three days, what is the smallest number of days that she would need to complete 6 of these rugs?

    a. add
    b. subtract
    c. multiply
    d. divide

18. A book club is giving its members a discount of $2.00 on each book. If the members buy a total of 1,721 books in a certain month, how much is the total discount for that month?

    a. divide
    b. multiply
    c. subtract
    d. add

19. If 2 inches are added to the length of a rectangle, its area is increased by 1/2 sq. inch. What is the height of the rectangle?

    a. divide
    b. add
    c. multiply
    d. subtract

20. A salesman needed to drive the 250 miles from New York City to Boston, Mass. If he left N.Y.C. at 7:30 A.M. and arrived in Boston at 12:30 P.M., what was his average speed in miles per hour?

    a. add and subtract
    b. divide and multiply
    c. multiply and add
    d. subtract and divide

GO ON TO THE NEXT PAGE.

Part 2 (continued)

21. A particular color television set can be purchased with cash for $340, or it can be purchased on the installment plan for $22 a month for 18 months. How much more would the television set cost on the installment plan?

    a. multiply and add
    b. add and divide
    c. subtract and divide
    d. multiply and subtract

22. A newsstand buys newspapers for 3 cents each and sells them for 5 cents each. How many papers must be sold to make a profit of $4.00 per day?

    a. subtract and divide
    b. multiply and subtract
    c. divide and multiply
    d. add and divide

23. At the first of the year, a store's inventory showed goods worth $31,250. During February the store purchased merchandise worth $29,834. In March a fire completely destroyed the store. If the owner claimed a merchandise loss of $47,420, how much merchandise had been sold before the fire occurred?

    a. multiply and subtract
    b. subtract and add
    c. multiply and add
    d. add and subtract

24. A clothing store took in $93,752 in cash from one year's sales. At the end of the year there was also $7,952 outstanding in uncollected accounts. If the store expects to collect 95% of these accounts, how much will it eventuall take in for the year's sales?

    a. subtract and multiply
    b. divide and add
    c. subtract and divide
    d. multiply and add

25. A topographical map on which 1 inch equals 50 miles shows that a point 1 inch from the seacoast is 1,500 feet above sea level. What is the average number of feet that the terrain must climb every 5 miles in order to reach that height?

    a. multiply and subtract
    b. divide and divide
    c. add and divide
    d. multiply and multiply

GO ON TO THE NEXT PAGE.

Part 2 (continued)

26. A farmer has his home and barn insured for $52,000. The yearly premium rate is $2.07 per $100. How much does this insurance cost him each year?

    a. divide and add
    b. add and multiply
    c. divide and multiply
    d. subtract and divide

27. John, who is eight years old, has been given an allowance of 25 cents per week. Each year he will get a raise of 20 cents per week. How much will his weekly allowance be 10 years from now?

    a. multiply and add
    b. subtract and divide
    c. divide and subtract
    d. add and multiply

28. A man owns a power boat which uses 54 gallons of gasoline every 6 hours when it is cruising at 1/4 throttle. If the same boat uses 20 gallons an hour when it is running at 3/4 throttle, how many fewer gallons are used per hour at 1/4 than at 3/4 throttle?

    a. multiply and multiply
    b. add and divide
    c. divide and subtract
    d. subtract and add

29. At present, Mr. Williams receives an annual interest of $42 from a $910 investment. He wants to increase his investment so that he will get $437 interest annually. What is the total amount that he must have invested at the same rate of interest?

    a. divide and divide
    b. subtract and divide
    c. multiply and subtract
    d. add and multiply

30. A motorist spent $31.20 for gasoline in the first 4 days of a 20 day trip. At this rate what will his gasoline expenditure be for the entire trip?

    a. multiply and add
    b. divide and multiply
    c. add and divide
    d. subtract and multiply

DO NOT GO BACK TO PART 1

STOP

DIRECTIONS: MARK YOUR ANSWERS ON THE SEPARATE ANSWER SHEET. CHOOSE THE BEST ANSWER FOR EACH QUESTION. (Note: for all questions involving turtle designs, the drawing for all designs started from HOME position.)

1. Logo is
   A. a graphics screen
   B. a turtle
   C. a programming language
   D. a computer system

2. LogoWriter was developed by
   A. Seymour Logo
   B. Janice Flake
   C. Seymour Papert
   D. Jean Piaget

3. The philosophy underlying the development of Logo was to create an educational language to:
   A. learn how to think
   B. develop problem solving skills
   C. be open for discovery
   D. all of the above

4. The directions that you give the turtle
   A. are based on your position as you face the screen
   B. are based on the turtle's current position
   C. are based on the directions on a compass
   D. all of the above

5. In the following procedure, what type of loop is used?

```
TO DESIGN :R
REPEAT 6 [FD :R RT 60 ]
DESIGN :R * 2
END
```

   A. Infinite
   B. Singular
   C. Finite
   D. All of the above

6. As the procedure given in problem 5 is executed, the figure that is being drawn
   A. gets larger
   B. gets smaller
   C. remains constant
   D. is not affected by :R * 2

7. To save a procedure named robot on your LogoWriter data disk, you would use the command:
   - A. np"robot
   - B. np "robot.logo
   - C. np "robot
   - D. np "robot"

8. What command erases all drawings, changes the background to black, turtle to white, puts the pen down, and sets the turtle shape in home position.
   - A. rg
   - B. ct
   - C. ht
   - D. cg

9. To erase the character to the left of the cursor, backspace by using the
   - A. ESC key
   - B. DELETE key
   - C. Open-Apple and 6 keys
   - D. ← key

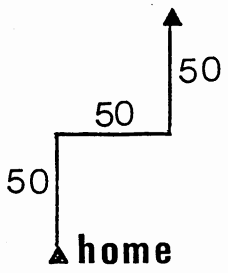
10. The part of the computer's memory that is available to hold variables and procedures as long as the computer is turned on called
    - A. Front side
    - B. Scrapbook page
    - C. Workspace
    - D. Flip side

11. The name of a procedure, must
    - A. begin with a letter
    - B. have no blank spaces
    - C. not be a LogoWriter primitive
    - D. all of the above

12. To define a new LogoWriter procedure for your Scrapbook page, you need to:
    - A. hold down Open-apple key and press G
    - B. hold down Open-apple key and press F
    - C. hold down Open-apple key and press S
    - D. hold down Open-apple key and press E

13. To erase a Scrapbook page (file) from the Contents Menu of your LogoWriter disk you need to:
    - A. hold down Open-apple key and press 6
    - B. hold down Open-apple key and press 9
    - C. hold down Open-apple key and press 8
    - D. hold down Open-apple key and press F

14. In order to make the turtle draw the design to the left, what should you type?



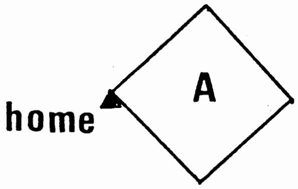
A. fd 50 rt 90 fd 50 rt 90 fd 50
B. fd 50 rt 90 fd 50 lt 90 fd 50
C. repeat 3[fd 50 rt 90]
D. repeat 2[fd 50 lt 90] fd 50

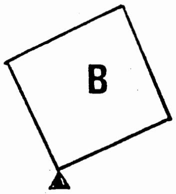
Use the following procedures for questions 15-17.

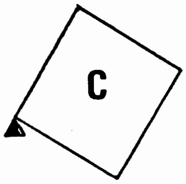
```
TO FIGURE :L
REPEAT 4[FD :L RT 90]
END
```

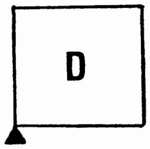
```
TO MOREFIGURES
FIGURE 60
RT 90 fd 60
FIGURE 40
RT 90
FIGURE 20
END
```

15. If figure 50 was typed and the return key was pressed, what would you see on the screen.



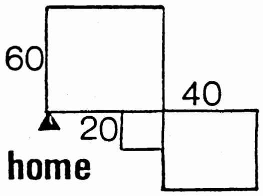




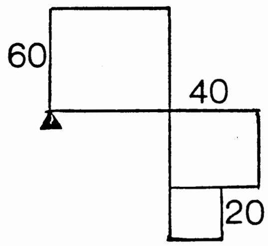


16. If MOREFIGURES was typed and the return key was pressed, what you would see on the screen.

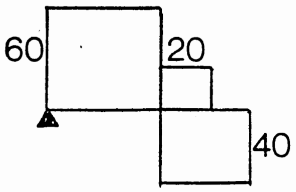
A



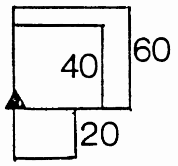
B



C



D



17. In the above procedure
    A. MOREFIGURES is subprocedure and FIGURE is superprocedure
    B. FIGURE is subprocedure and MOREFIGURES is superprocedure
    C. both A and B
    D. neither A or B

18. Recursion is LogoWriter's ability to
    A. repeat a series of steps a fixed number of times.
    B. write procedures that use their own name in their directions.
    C. understand a series of command named by the programmer.
    D. execute three different procedures at one time.

19. Which one of the following procedures makes a set of triangles that continue to increase in size.

A.

```
TO TRI :SIZE
REPEAT 3[FD :SIZE RT 120]
TRI :SIZE - .20
END
```

B.

```
TO TRI :SIZE
REPEAT 3 [FD :SIZE RT 120]
TRI :SIZE * .10
END
```

C.

```
TO TRI :SIZE
REPEAT 3 [FD :SIZE RT 120 ]
TRI :SIZE
END
```

D.

```
TO TRI
REPEAT 3 [FD :SIZE RT 120 ]
TRI :SIZE + 10
END
```

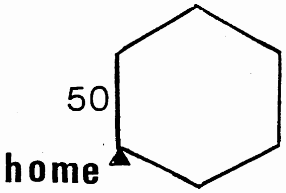
20. In the following procedure if you typed square and pressed return, what would happen?

```
TO SQUARE :SIZE
REPEAT 4[FD :SIZE RT 90 ]
END
```

A. I don't know what to do with square
B. I don't know how to square
C. I'm having trouble with the disk or drive
D. Square needs more input

21. The procedure polygon has been defined, in order to see the following hexagon with each side 50 what do you need to type?

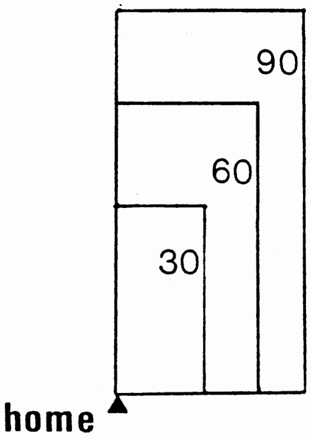
```
TO POLYGON :N :L
REPEAT :N [FD :L RT 360/ :N]
END
```



A. polygon :6 :50
B. polygon 50 6
C. polygon 6 50
D. polygon :50 :6

22. To write a superprocedure that draws the rectangles picture below, which the height of each rectangle is twice the width, what would you type?

```
TO RECT :L
REPEAT 2[FD :L RT 90 FD :L /2 RT 90]
END
```



A.
```
TO DOUBLE
HT RECT 30 RECT 60 RECT 90
END
```

B.
```
TO DOUBLE
HT RECT 90 RECT 30 RECT 60
END
```

C.
```
TO DOUBLE
HT RECT 90 RECT 60 RECT 30
END
```

D. ALL OF THE ABOVE

23. What happens if you start the procedure below with the input 10.

```
TO SQUARE :SIZE
IF :SIZE > 20[STOP]
FD :SIZE RT 90
SQUARE :SIZE +3
END
```

A. it dosen't stop
B. nothing - the procedure still stops
C. when the value for :size is greater than 20 then the procedure stops.
D. when the value for :size is less than 20 then the procedure stops.

24. An organized collection of information that has been stored on a disk is called:

A. a command center
B. a catalog
C. a directory
D. a file

25. Identify the correct condition and steps that are necessary to fill a shape:
A. the shape must be closed; pick the pen up, put the turtle inside the area to be filled, put the pen down, and fill.

B. the shape must be closed; put the turtle inside the area to be filled, and fill.

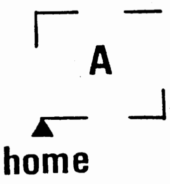
C. the shape must be open; pick the pen up, put the turtle inside the area to be filled, put the pen dawn, and fill.

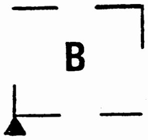
D. the shape must be closed; pick the pen up, put the turtle inside the area to be filled, and fill.

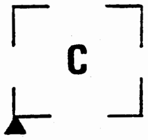
26. The display area of a LogoWriter Scrapbook page where you may draw or write text is called the:
A. command center
B. front side
C. flip side
D. contents menu

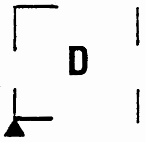
27. Identify the sketch that is drawn when the following procedure is executed:

```
TO SQUARE
REPEAT 4[FD 10 PU FD 20 PD FD 10 RT
90]
END
```









28. What procedure draws a circle when executed?
A.
```
TO CIRCLE :S
REPEAT 4 [FD :S  RT 10]
END
```

B.
```
TO CIRCLE :S
REPEAT 30 [FD :S RT 360/ :S]
END
```

C.
```
TO CIRCLE :S
REPEAT 36 [FD :S  RT 10]
END
```

D.
```
TO CIRCLE :S
REPEAT 36 [FD 10 RT 10 ]
END
```

29. The process of breaking down a complex picture into its component parts is called:
A. debugging
B. top-down analysis
C. bottom-up analysis
D. all of the above

30. Using the procedure TRI, identify the TRI4 procedure that draws the pinwheel design when executed.

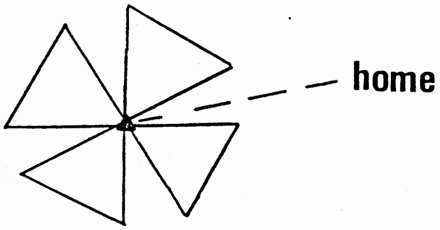
```
TO TRI
REPEAT 3 [ FD 40 RT 120]
END
```

A.
```
TO TRI4
REPEAT 4 [ TRI RT 60]
END
```

B.
```
TO TRI4
REPEAT 4 [TRI RT 120]
END
```

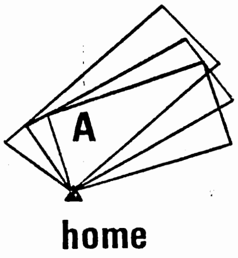
C.
```
TO TRI4
REPEAT 4 [TRI RT 90]
END
```

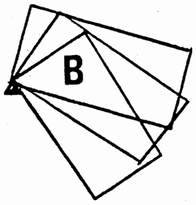
D.
```
TO TRI4
REPEAT 4 [TRI RT 45]
END
```

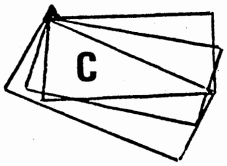


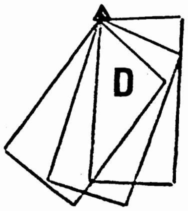
31. Using the procedure RECTANGLES, what would the turtle draw if the procedure MORERECTANGLES were executed.

```
TO RECTANGLE
REPEAT 2[FD 20 RT 90 FD 40 RT 90]
END

TO MORERECTANGLES
REPEAT 3[RT 20 RECTANGLE]
END
```

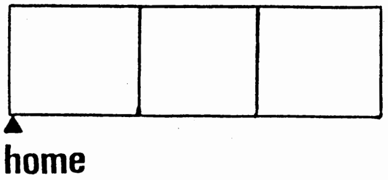








32.



Using the procedure BOX, which ROW procedure draws the design to the left when executed?

```
TO BOX
REPEAT 4[FD 40 RT 90]
END
```

A.
```
TO ROW
REPEAT 3[BOX LT 90 FD 80 RT 90]
END
```

B.
```
TO ROW
REPEAT 3[BOX LT 90 FD 20 RT 90]
END
```

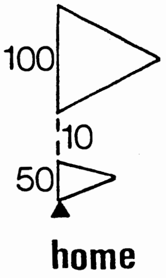
C.
```
TO ROW
REPEAT 3[BOX RT 90 FD 20 LT 90]
END
```

D.
```
TO ROW
REPEAT 3[BOX RT 90 FD 40 LT 90]
END
```

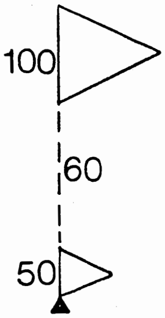
33. What do you think the turtle will draw for the procedure PRETTY.

```
TO TRIANGLE :SIDE
REPEAT 3 [FD :SIDE RT 120]
END

TO MOVE
PU FD 60 PD
END

TO PRETTY
TRIANGLE 50
MOVE
TRIANGLE 100
END
```

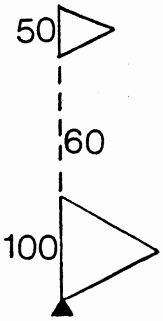
A



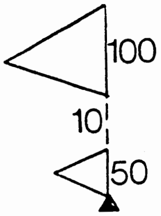
B



C



D



APPENDIX B

CONTENT OBJECTIVES AND TEACHING SCHEDULE

CONTENT OBJECTIVES AND TEACHING SCHEDULE

WEEK ONE

Objectives: the student will be able to:

1) discuss Logo's origins, philosophy and the difference between Logo and LogoWriter.
2) identify the commands that control the turtle and the graphics screen.
3) use the turtle commands to duplicate on the screen a figure from paper.

WEEK TWO

Objectives: the student will be able to:

1) write and define procedures.
2) recognize repeating patterns and use the repeat command in procedures.
3) debug and make changes in procedures.
4) utilize and define a scrapbook page (flip side and front side).
5) save a scrapbook page.
6) utilize LogoWriter special key functions.

WEEK THREE

Objectives: the student will be able to:

1) break down a Logo problem into smaller parts and write a subprocedure for each part.
2) combine subprocedures into a superprocedure.
3) define and utilize a variable in a procedure.
4) use more than one variable in a single procedure.

WEEK FOUR

Objectives: the student will be able to:

1) use several subprocedure and superprocedure.
2) draw different sizes of circles by using variable input.
3) draw turtle graphics using STAMP, SHAPES, TURTLE-MOVE KEY AND LABEL KEY.

WEEK FIVE

Objectives: the student will be able to:

1) discuss the concept of recursion and use it in defining procedures.
2) use variables and conditional statements in recursive procedures.
3) recognize and apply recursion in appropriate problem-solving situations.

APPENDIX C

SAMPLE OF LABORATORY ASSIGNMENTS AND OUTSIDE ACTIVITIES FOR HIGH STRUCTURE TREATMENT

(WEEK 3)

1. **What do you think the turtle will draw when given each of these commands? Sketch your guess. Then check your prediction by teaching the turtle the new procedure. If your prediction was inaccurate, correct your sketch.**

a.

```
TO LINE1
FD 50
BK 50
END
```

Sketch:

b.

```
TO LINE2
FD 30
BK 30
END
```

Sketch:

c.

```
TO LINE3
FD 20
BK 20
END
```

Sketch:

d.

```
TO SHINE
REPEAT 9[LINE1 RT 10 LINE2 RT 10 LINE3 RT 10 LINE2 RT 10]
END
```

Sketch:

e.

```
TO GRASS
LINE3
REPEAT 10[RT 90 FD 4 LT 90 LINE2 RT 90 FD 4 LT 90 LINE3]
END
```

Sketch:

2. Save these procedures as a page on your files disk. Record the words defined on this page.

Disk page title: ____________________

Words defined:

What do you think the turtle will draw when given each of the commands defined below? Sketch your guess. Then check your prediction by teaching the turtle the new procedure. If your prediction was inaccurate, correct your sketch.

1. a.

```
TO REC
FD 60
RT 90
FD 20
RT 90
FD 60
RT 90
FD 20
RT 90
END
```

Sketch:

b.

```
TO FOUR
REPEAT 4[REC RT 90]
END
```

Sketch:

c.

```
TO VEE
LT 45
FD 30
BK 30
RT 90
FD 30
BK 30
LT 45
END
```

Sketch:

d.

```
TO PRETTY
REPEAT 2[FOUR RT 45]
LT 90
BK
VEE
END
```

Sketch:

2. Save these words as a page on your files disk. Use the title RECTANGLES. Record the words defined in RECTANGLES.

Disk page title: RECTANGLES

Words defined: ____________________

____

____

____

When you give the command PENUP, the turtle follows the command and picks up the pen. But when you give the command FORWARD, the turtle gives you a message indicating that FORWARD needs more *input*. The turtle needs to know "how far" FORWARD.

You can create procedures like FORWARD that require input by using variable names like :L, or :LENGTH, or :SIDE.

Teach the turtle each of the procedures below, which use input. Test each procedure by giving the turtle three commands. Describe or draw what the turtle does in response to each command.

Procedure	**Test commands and turtle's responses**

1. `TO LINE :L`
`FD :L`
`BK :L`
`END`
	a. `LINE`
	b. `LINE 20`
	c. `LINE 30`

2. `TO SQUARE :LENGTH`
`REPEAT 4[FD :LENGTH RT 90]`
`END`
	a. `SQUARE`
	b. `SQUARE 30`
	c. `SQUARE 50`

3. `TO TRIANGLE :SIDE`
`REPEAT 3[FD :SIDE RT 120]`
`END`
	a. `TRIANGLE`
	b. `TRIANGLE 40`
	c. `TRIANGLE 70`

POLYGON is a procedure that commands the turtle to draw a regular polygon with :N sides and with the length of each side 30 turtle steps.

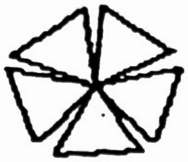
```
TO POLYGON :N
REPEAT :N[FD 30 RT 360/:N]
END
```

SPIN.POLYGON is a procedure that commands the turtle to spin an :N- sided polygon a specific number of times, :T.

```
TO SPIN.POLYGON :N :T
REPEAT :T[POLYGON:N RT 360/:T]
END
```

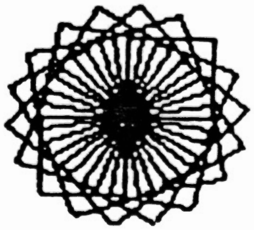
The designs below were created using SPIN.POLYGON. Find the command that created each design. To check your answers, teach the turtle the two procedures and then give the turtle your commands.

1.



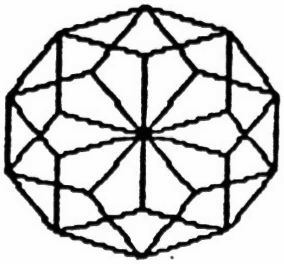
CG
SPIN.POLYGON 3 5

2.



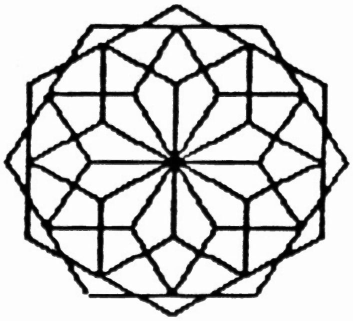
CG
SPIN.POLYGON 4 18

3.



CG
SPIN.POLYGON 5 10

4.



CG
SPIN.POLYGON 6 12

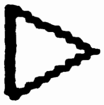
APPENDIX D

SAMPLE OF LABORATORY ASSIGNMENTS AND OUTSIDE ACTIVITIES FOR LOW STRUCTURE TREATMENT

(WEEK 3)

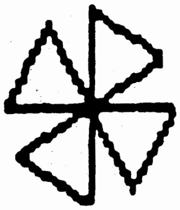
What can a turtle do if it knows how to TRI? Teach the turtle the procedure TRI.

```
TO TRI
REPEAT 3[FD 40 RT 120]
END
```



Now have the turtle draw the designs below by creating new procedures that use the command TRI.

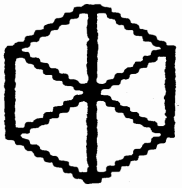
1.



Procedure:

```
TO TRI4
```

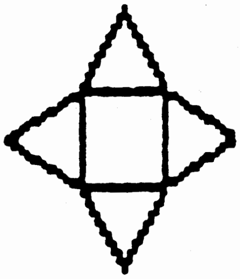
2.



Procedure:

```
TO TRI6
```

3.



Procedure:

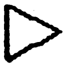
```
TO STAR
```

1. Create a procedure for a rectangle that is 50 turtle steps high and 25 turtle steps wide. Record your procedure.

Procedure:

```
TO REC
```

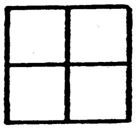
2. Create a procedure for a triangle that is 25 turtle steps on each side. Record your procedure.



Procedure:

```
TO TRI
```

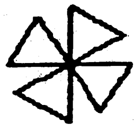
3. Can you create this design using REC? Record your procedure.



Procedure:

```
TO USE.REC
```

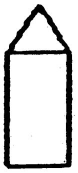
4. Can you create this design using TRI? Record your procedure.



Procedure:

```
TO USE.TRI
```

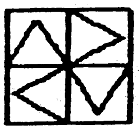
5. Can you create this design using the procedures you have created this far? Record your procedure.



Procedure:

```
TO TRI.REC
```

6. Can you create this design using your procedures? Record your procedure.



Procedure:

7. Save these procedures on your files disk.

When you give the command PENUP, the turtle follows the command and picks up the pen. But when you give the command FORWARD, the turtle gives you a message indicating that FORWARD needs more *input*. The turtle needs to know "how far" FORWARD.

You can create procedures like FORWARD that require input by using variable names like :L, or :LENGTH, or :SIDE.

Teach the turtle each of the procedures below, which use input. Test each procedure by giving the turtle three commands. Describe or draw what the turtle does in response to each command.

Procedure	Test commands and turtle's responses
1. TO LINE :L	a. LINE b. LINE 20 c. LINE 30
2. TO SQUARE :LENGTH	a. SQUARE b. SQUARE 30 c. SQUARE 50
3. TO TRIANGLE :SIDE	a. TRIANGLE b. TRIANGLE 40 c. TRIANGLE 70

POLYGON is a procedure that commands the turtle to draw a regular polygon with :N sides and with the length of each side 30 turtle steps.

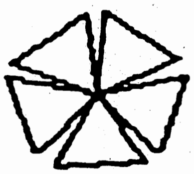
```
TO POLYGON :N
REPEAT :N[FD 30 RT 360/:N]
END
```

SPIN.POLYGON is a procedure that commands the turtle to spin an :N-sided polygon a specific number of times, :T.

```
TO SPIN.POLYGON :N :T
REPEAT :T[POLYGON:N RT 360/:T]
END
```

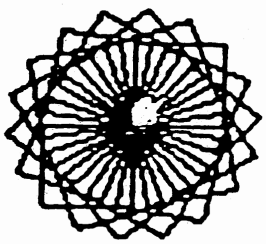
The designs below were created using SPIN.POLYGON. Find the command that created each design. To check your answers, teach the turtle the two procedures and then give the turtle your commands.

1.



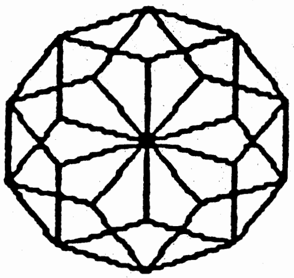
SPIN.POLYGON ___ ___

2.



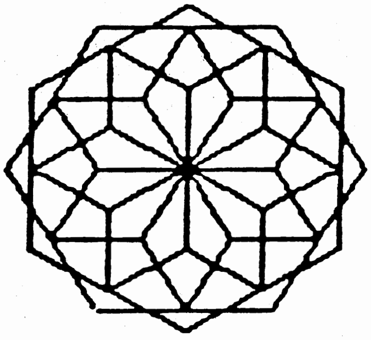
SPIN.POLYGON ___ ___

3.



SPIN.POLYGON ___ ___

4.



SPIN.POLYGON ___ ___

VITA

Sedigh Kouchak

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Education: Graduated from Behazin High School, Tehran, Iran, 1975; received the Bachelor of Science degree in Educational Psychology from Pars University, Tehran, Iran, 1978; received the Master of Education degree in Educational Technology from the University of Oklahoma, Norman, Oklahoma, 1981; completed requirements for the Doctor of Education degree from Oklahoma State University, Stillwater, Oklahoma in May, 1989.

Professional Experience: Entered the teaching profession in Tehran, Iran in 1977 as an kindergarten teacher for ages 5 and 6 for two years; Graduate Assistant at University of Oklahoma, 1982-1984; Research Assistant, Computer Lab, Oklahoma State University, 1985-1986; Graduate Teaching Assistant at Oklahoma State University, 1986-1989.