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An analysis of cognitive style, grade level and spatial sequencing during LOGO mastery

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AN ANALYSIS OF COGNITIVE STYLE, GRADE LEVEL AND SPATIAL SEQUENCING DURING LOGO MASTERY

by

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APPROVAL PAGE

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This study empirically investigated how cognitive style and grade level relate to spatial development and comprehension monitoring. Eighty subjects participated in the study. These subjects were in the fifth (20 Field Dependent (FD)/20 Field Independent (FI)) and in the second grade (20 Field Dependent (FD)/20 Field Independent (FI)). The subjects were instructed over a five day period in fundamental LOGO commands. Once these skills had been learned, the subjects were required to complete a series of three card sets each requiring them to replicate four problem-solving tasks. These tasks consisted of 90 degree turns only, 45 and 90 degree turns, and 45 degree turns only. Results for comprehension monitoring were determined from the subject's scores on the Comprehension Monitoring Score Sheet.

It was concluded from this study that cognitive style and grade level, when evaluated together, provided information about spatial development and comprehension monitoring that would have been masked if only one of the variables had been used. This analysis further provided support for Campbell, et al., (1986) and Watson and Busch's (1989) position that subjects first use egocentric strategies (pointing and the use of a grid system) when first learning LOGO programming, and then develop the ability to view the positioning of the turtle as the point

from which further movements are made (using a concentric circles system). The development of this new perspective allows the child increased flexibility when problem-solving with LOGO.

The study also found that a subject's ability to problem-solve was related to the quadrant in which they were working. Related to this was the finding that subjects in different grade levels and having different cognitive styles had difficulty problem-solving in different quadrants. For example, second grade field dependents had difficulty in the lower right and left quadrants, while fifth grade field dependents had difficulty in the upper left.

Finally, measures of comprehension monitoring differed between groups based on cognitive style and grade level. In general, fifth grade field independent subjects were found to have scored the highest in comprehension monitoring scores, and second grade field dependent individuals to have scored the least.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

Computers are becoming integrated into all aspects of our culture. Computers have generated fertile debate among educators, especially concerning the programming language LOGO. Some researchers (Barnes & Hill, 1983; Brady & Hill, 1984) have argued that it is not appropriate for preoperational children to learn abstract computer tasks. Others (Shade & Watson, 1987; Clements, 1986; Miller & Emihovich, 1986) have demonstrated that children as young as 4 years old are able to learn enough LOGO syntax to manipulate the "turtle" within the computer's microworld.

In Mindstorms, Papert (1980) argues that programming with LOGO can increase a child's intellectual ability. Papert states that with LOGO "knowledge that was accessible only through formal processes can now be approached concretely. And the real magic comes from the fact that this knowledge includes those elements one needs to become a formal thinker" (p. 21). Put differently, LOGO provides an enriched environment that shifts the boundaries that separate concrete from formal thinking, and possibly lowers the age at which children are able to deal with abstractions.

This suggestion of accelerated cognitive development (especially in the areas of logical thinking and mathematics) encouraged educators to begin using LOGO when instructing schoolchildren. Research evaluating this instruction has reported mixed results. Several large computer projects--- the Bank Street College Project, the University of Israel project, and a study completed at the University of Edinburgh--- reported that extended LOGO instruction did not provide significant gains in children's problem-solving and mathematical skills over non-LOGO instruction (Rieber, 1987; Many, Lockard & Abrams, 1988; Kurland & Pea, 1985; Hawkins, Sheingold, Gearhart, & Berger, 1982). Other studies (Clements, 1985; Clements & Gullo, 1984) demonstrated positive effects on children's problem-solving abilities.

Rieber (1987), writing in response to studies producing negative results, states that Papert developed LOGO to be "part of a cultural influence and that considering LOGO by itself, without associated cultural factors, is devoid of meaning" (p. 13). Watson, Chadwick, and Brinkley (1987) also support Riebner's contention and write that "Papert believes that the child must be immersed in a computer (Logo) culture before such profound changes may be evaluated" (p. 204).

While reporting negative results from LOGO programming, Pea and Kurland (1984) also wrote that the "task of learning to program has not thus far been subjected to developmental analysis or characterized in terms of its component skills" (p. 49). Extending this idea, and responding to critics of LOGO, Emihovich & Miller (1988) suggest that LOGO is more than a programming language or instructional method, and actually creates a "context for learning". Within this "context", the way children learn to program becomes as important as the products of their learning. Little has been written to date, but studies focusing on the way children learn to program have been conducted by Clements and Gullo (1984); Campbell, Fein, Scholnick, Schwartz, and Frank (1986); Solomon and Perkins (1987); Watson, Lange, and Brinkley (1989); Brinkley (1989).

Evaluating LOGO programming, and providing alternative explanations for negative results, Clements and Gullo (1984) and Miller & Emihovich (1986) maintain that the studies which were unsuccessful utilized "Piagetian Learning" or learning by discovery. This method teaches children how to program in LOGO, and then lets them explore LOGO on their own. In contrast to this, the studies that reported positive results employed "mediated" LOGO instruction. Miller and Emihovich (1986) write that during mediated instruction, a "competent tutor provides guidance or scaffolding to help bridge the learner's background knowledge and present skills with the new ideas that are acquired through LOGO programming" (p. 285).

Another line of process-oriented studies have concentrated on spatial development (Fay & Mayer, 1987; Gallini, 1987, Campbell, et al., 1986). These researchers have begun to identify the predominant manipulations, movements, and instructions needed when replicating a pattern using LOGO commands. Their results suggest that "Forward" commands are easier than "Backward", and that "Right" commands are easier than "Left".

Canino and Cicchelli (1988) and Smith (1984-85) have studied the effect stylistic differences have on LOGO programming processes. Canino and Cicchelli (1988) studied cognitive style as it relates to two computerized instructional methodologies (algorithmic and discovery). They reported that cognitive style is responsive to instructional method.

Smith (1984-85) evaluated the effect of computer instruction on the performance of field dependent/field independent students learning a specific skill (comma usage). She found that students who were classified as field independent scored significantly better in learning comma usage than those who were field dependent. She concluded that computer instruction can be beneficial to field independent students.

In summary, as researchers have evaluated the processes children use when learning to program with LOGO, they have identified several factors which contribute to this learning. These include the child's spatial development (Gallini, 1987; Fay & Mayer, 1987; Campbell, et al., 1986), the instructional method used (Clements & Gullo, 1984; Emihovich & Miller, 1986), and differences in cognitive style (Canino & Cicchelli, 1988; Smith, 1984-85).

Statement of the Problem

Recent studies have begun to provide information concerning the processes children use when programming with LOGO. LOGO is a computer programming language in which "turtle" or LOGO cursor is used as an "object to think with" and allowing for the external expression of abstract ideas and thoughts. These studies accounted for differences relating to children's perceptions of LOGO tasks and mastery of required LOGO mamipulations. The present study investigated the relationship between spatial development, instructional methodology, and stylistic differences as related to problem-solving tasks using LOGO programming skills. Three research questions were asked:

1. Will field independent-field dependent children of differing grade levels perform differently on a set of cards containing one pattern which has been rotated in four positions (0 degrees, 90 degrees, 180 degrees, 270 degrees)?
2. Will field independent-field dependent children of differing grade levels perform differently between card sets representing 90 degree turns only (a grid system), 90 degree

and 45 degree turns (a grid system plus beginning concentric circle), and 45 degree turns only (concentric circle system)?

3. Will field independent-field dependent children of the same and differing grade levels differ in their development of comprehension monitoring skills? Findings that are not specifically requested by the three research questions, but are of research interest will be discussed. These additional descriptions may assist in the explanation of primary findings and in their implications.

Hypotheses

Based on the problem statements the following hypotheses are presented:

H1 There will be a significant pattern rotation (quadrant) effect found within a group of subjects (for example second grade field independents) based on cognitive style and grade level as measured by partial time for task completion and total number of keystrokes used to complete one-half of the problem-solving task.

(A) Subjects replicating the pattern in the upper right quadrant (0 degree rotation) will do significantly better as measured by taking less time and using fewer commands to replicate one-half of the pattern.

(B) Subjects replicating the pattern in the lower left quadrant (180 degree rotation) will do significantly poorer as measured by taking more time and using more strokes to replicate one-half the pattern.

H2 There will be a significant pattern rotation (quadrant) effect found between subjects (for example second grade field independents compared or contrasted with second grade field dependents) based on cognitive style and grade level as measured by partial time for task completion and total number of keystrokes used to complete one-half of the problem-solving task.

(A) Fifth-grade field independent (5FI) subjects will score lower on the dependent measures (partial time to task completion and total number of keystrokes used) when problem-solving in all quadrants for the three card sets than will the other groups of subjects (5FD, 2FI, and 2FD).

(B) Fifth-grade field dependent (5FD) subjects will have significantly lower scores on all dependent measures (partial time to task completion and total number of keystrokes used) for Card Sets 1 and 2 as compared to 2FI or 2FD subjects.

(C) Second-grade field independent (2FI) subjects will score significantly lower on all dependent measures (partial time to task completion and total number of keystrokes used) for Card Sets 1, 2, and 3

H3 There will be significant differences between subjects based on cognitive style and grade level as measured by discrete measures of comprehension monitoring.

(A) Fifth-grade field independent subjects will score significantly higher on all measures (questions concerning hypothesis generation, planning ahead, comparing alternatives, evaluation of outcomes, and total score) for all card sets than will all other groups of children.

(B) Fifth-grade field dependent subjects will score significantly higher on all dependent measures for Card Sets 1 and 2 when compared to 2FI and 2FD subjects.

(C) Second-grade field independent subjects will score significantly higher on all dependent measures for Card Sets 1 and 2 than will field dependent second graders.

Improtance of the Study

Dunn, Dunn, & Price (1977) and Saracho (1984) write that the most significant factor determining a children's success at school may be the way they manipulate and process information-the way they learn. Cognitive styles are aggregate personality characteristics that determine how information is perceived, remembered, and processed (Saracho,1984; Witkin, Goodenough, & Karp, 1967; Saracho & Spodek, 1981). This study is limited to investigating the effects of the cognitive styles field independence and field dependence. Field dependent learners need external reinforcement and frequently ignore cues from the environment. Field independent learners, on the other hand, are internally motivated and utilize the existing cues from the environment.

According to Piagetian theory (Rohwer, Ammon, & Cramer, 1974; Mussen, Conger, Kage, & Huston, 1984) second grade students would be operating withing a transitional stage between preoperations and concrete operations. During this stage children are beginning to engage in representational thought and are less egocentric than they were previously. These children, however, are still unable to perform tasks that require the conservation of numbers, mass, and area. Fifth grade students, on the other hand, are operating within the concrete operations stage. The children can now approach problems with more logic and have developed coordinated mental structures that permit decentration and reversibility. The children can now respond to problems that require focusing on more than one aspect at a time.

Children working with a LOGO microworld environment are operating within an abstract, small-scale environment. Piaget and Inhelder (Lowery & Knuck, (1982-1983) have identified three stages of spatial development. These are the Topological, the Projective, and the Euclidean. During the Topological stage children learn about space from an egocentric perspective. During the Projective stage, children are able to view objects from an imaginary "other" perspective. Finally, children operating within a Euclidean perspective understand the relationships of area, angle, and distance. Papert writes that LOGO allows children to operate within a Euclidean frame of reference (moving up, down, right, left) even if they have not reached that stage of development. Within the LOGO microworld children can maintain an egocentric perspective and still manipulate the turtle.

Campbell, Fein, Scholnick, Schwartz, and Frank (1986) have written that children begin to manipulate the turtle using a rectangular coordinate (grid) system. From this system the children learn to move on a diagonal by learning to view the computer screen as no longer made up of a pattern of grids, but as a polar coordinate (concentric circle) system. This new perspective allows these children to maximize flexibility of movement through complementary reciprocal distance and direction commands.

Recent research (Brinkley, 1989; Fay & Mayer, 1987; Gallini, 1987; Campbell, et al., 1986; Clements & Gullo, 1984; Miller & Emihovich, 1986; Solomon & Perkins, 1987; Watson, Brinkley, Ingles, Howard, Sheets, Hatfield, Myrick, Prola, & Penny, 1988; Saracho & Spodek, 1981; Saracho, 1984) into the processes children use when learning to program with LOGO have identified several factors associated with this learning. These factors include spatial development, cognitive style, and instructional method. The studies cited generally were limited to a single factor measured for a single grade level or for two grade levels. The present study provides for the inclusion of cognitive style and grade level as factors for investigating spatial development across grade levels and stages of development. By focusing on these variables in combination, it will be possible to identify whether field independent children are better able to complete a LOGO problem-solving task than field dependent children of a particular grade level and across grade levels representing differing stages of spatial development.

As also mentioned above, the instructional method used has also had an influence on children's learning to program with LOGO. The present study employed the comprehension monitoring model developed by Miller (1985). This model provides a framework within which the skills necessary for completing LOGO problem-solving tasks can be developed. Studies to date (Miller & Emohovich (1986); Gallini (1987)) have researched whether LOGO programming as opposed to computer-aided instruction (CAI) impacts upon comprehension monitoring. This study has focused on how being trained in a specific technique of comprehension monitoring can influence the completion of LOGO problem-solving tasks. By focusing on comprehension monitoring it will be possible to again determine whether field independent subjects are better able to develop these comprehension monitoring skills than field dependent subjects at a particular grade level and across grade levels.

Assumptions and Limitations

Assumptions

The major assumption being made in this study is that the card sets developed for this study will be distinctly different from each other to adequately distinguish between children at the different stages of Piagetian development. It is also assumed that these card sets adequately represent the grid and concentric circle systems described by Campbell, et al., (1986). Futhermore, it is assumed that cognitive style remains relatively stable during the elementary years and can be measured.

It is also assumed that the time limits set in this study for training and for problem-solving are adequate for the results.

Limitations

Repeated measures ANOVA (Keppel, 1982) is an analytical technique that can be used when the same variable is measured on several occasions for each subject. In this study the same figure (problem-solving task) is being replicated each time, only rotated 90 degrees. This analytical method, however, can have several limitations. These limitations include its sensitivity to a carry-over effect, a latent effect, and an order or learning effect. The carry-over effect occurs when a new treatment is administered before the effect of a previous treatment has worn off. The latent effect occurs when one treatment may activate the dormant effect of the previous treatment or interacts with the previous treatment. This generally refers to studies involving drug treatments or medicines. Finally, this method is sensitive to a learning effect. This effects occurs when the response may improve memory by repetition of the task, independent of any treatment.

This study has attempted to neutralize these effects or limitations by first making the card sets different enough so that one problem-solving task requires the subjects to engage in a spatially different activity from the next. Each card set is also visually and spatially different, requiring the subject to again engage in spatially different activities from the other card sets. Finally, the design of this study provides that problem-solving tasks be presented in a counterbalanced manner so that a pattern of response would not form.

Definition of Terms

The following definition of key terms are provided for clarification. References following the definitions of independent variables refer to other studies that have utilized them.

Card Set. A card set consists of four problem-solving tasks cards. Each set contains one pattern that has been rotated in four positions ---0 degrees (upper right), 90 degrees (lower right), 180 degrees (lower left), and 270 degrees (upper left). There are four card sets that represent patterns that require 90 degree turns only (training set and problem-solving set 1), 90 degree and 45 degree turns (problem-solving set 2), and 45 degree turns only (problem-solving set 3).

Cognitive Style. Cognitive style refers to an individual variation in mode of perceiving, remembering, and thinking. While there are several dimensions of cognitive style, this study has focused on field independence and field dependence. Cognitive style is determined by scores on the Children's Embedded Figures Test.

Comprehension Monitoring. Comprehension monitoring is a metacognitive strategy that elicits comprehension information by asking individuals to plan ahead, give "next steps", evaluate completed work, and "debug" mistakes made. Comprehension monitoring is measured by scores on the Comprehension Monitoring Score Sheet.

Concentric Circle System. Within a concentric circle system the subject would not be restricted to movements that use 90 degree angles only. They are now aboe use obliques or diagonal angle movements also. (Campbell, et al., 1986)

Field dependence. Refers to a cognitive style in which a person relies predominantly on an external frame of reference when processing information. Field dependents demonstrate less cognitive restructuring on cognitive or perceptual tasks and respond to the context in which they are working as a whole.

Field Independence. Refers to a cognitive style in which a person relies primarily on an internal frame of reference when processing information. Field independents also demonstrate greater cognitive restructuring on cognitive or perceptual tasks.

Grid System. Within a grid system the subject would use manipulations that use only forward and backward, right and left commands at 90 degree angles only. Within this system there are no oblique or diagonal movements made. (Campbell, et al, 1986)

Grade Level. This refers to the actual grade placement of the subject at the time the study was conducted. Grade levels being used as part of this study are kindergarten, second and fifth.

Home Position. This is the position from which the "turtle" begins each time the screen has been cleared. The home position locates the turtle in the center of the monitor's screen pointing up toward the top of the screen. It is from this position that all further movements are made.

Partial Time for Task Completion. This is the time it takes for the subject to complete one-half of the task card.

LOGO. LOGO is the computer language developed by Seymour Papert in which communications with the turtle (LOGO cursor) takes place.

Pattern Rotation/Quadrant Effect. This is the phenomenon in which a pattern that is rotated in four positions, (0 degrees (upper right), 90 degrees (lower right), 180 degrees (lower left), and 270 degrees (upper left)), is replicated more accurately and with more efficiency in one position than another. If the computer's monitor screen were to be divided into four equal parts through the center of the screen four quadrants would be formed. Each of the four positions mentioned above represent the same pattern being drawn within each of the four quadrants formed.

Problem-solving Task. This is a pattern that the subject is required to replicate using LOGO commands.

Total Number of Commands. The total number of keystrokes made while completing a task card. This includes all steps, turns, and errors made. Steps are the Forward and Backward commands made. Turns are the Right and Left commands made. Errors are deviations from the a priori determined number of commands, mistakes made while typing, and confusions (see criteria in the Procedures section).

Turtle. The turtle is first the LOGO cursor. Secondly, it is a computer-controlled cybernetic animal, the "object-to-think-with" that exists within the LOGO microworld environment (Papert, 1980).

CHAPTER II

REVIEW OF THE LITERATURE

Little is known about how children learn to program with LOGO. Researchers are slowly improving this situation (Fay & Mayer, 1987; Campbell, et al., 1986; Miller & Emihovich, 1986; Clements & Gullo, 1984). This literature review includes an overview of important studies that have been conducted in this area. These relate to certain dependent variables and are followed by reviews related to certain independent variables. The final section provides a summary of the theoretical model on which this research is based.

Spatial Development

An important component of a child's development is learning the spatial qualities of his/her world (environment). Siegel and White (1975) view spatial development as changes within an individual's internal environmental representations; his/hers "cognitive maps". Cognitive maps are constructed in three successive developmental stages. These stages include the development of landmarks, routes, and configurations. Landmarks are "the strategic foci to and from which one travels" (p. 23).

While landmarks involve a predominantly visual cue, routes involve expectations about landmarks and other decision points. "If one knows at the beginning of a "journey" that one is going to see a particular landmark (or an ordered sequence of landmarks) one has a route" (Siegel & White, 1975, p. 24).

As individuals interact within their environment, they are confronted with hundreds of landmarks and routes. The cognitive structures that accommodate this information are configurations. Siegel (1978) writes that these "enhance way-finding and they may be a necessary condition for the invention of new routes" (p. 246). Configurations involve at least three types of knowledge; a perceived outline, a graphic skeleton or representation, and a figurative metaphor of the environment.

Piaget and Inhelder (1978) identified in children three stages of spatial development: Topological, Projective, and Euclidean. Lowery and Knirk (1982-1983, p. 156) define the Piaget and Inhelder stages as follows:

1. Topological--where one learns the interrelationships of space from an egocentric perspective.

2. Projective--where one is able to view objects from an imaginary "other" point of view; objects in the environment are viewed from another mental perspective.

3. Euclidean--where the relationships of area, angle, distance, and volume are understood.

Acredolo (1981) investigated large and small spatial environments and found that when encountering a new environment, children (and adults) tend to navigate using its most salient features or landmarks. However, when landmarks are absent, children use their own bodies as a frame of reference. Herman and Siegel (1978) studied the behavior of children in "bounded" (landmarked) and "unbounded" (not landmarked) environments, and found that children in a familiar small environment did significantly better than children in a large unbounded environment. Herman and Siegel concluded that while the child is able to operate in both bounded and unbounded environments, when landmarks are not available spatial performance is reduced.

While these studies have concentrated on children operating within a physical environment, results also can be applied to the child's operating within the abstract "microworld" of LOGO. Papert (1980) reported that one of the main features of LOGO programming is its ability to facilitate "syntonic learning" or learning that is related to children using their bodies as directional cues (standing, pointing, turning selves) for movement, or a sense of themselves as persons with goals and desires. In Piagetian terms, LOGO allows the child to operate within an Euclidean frame of reference (moving up, down, right, left, etc.) even if they have not reached that stage of development. LOGO permits the child to maintain an egocentric perspective and enables him/her to manipulate the turtle, the LOGO cursor, within the computer's microworld.

While the computer screen may be a new and unknown small-scale environment for a child, the principles of egocentric navigation (using the body) or exocentric navigation (using salient features of the surrounding environment) apply. The placement of the computer system within a room provides children with landmarks (cues) that permit them to focus on some object, decide which way to turn the turtle, and cause the turtle to move in that direction.

Brinkley (1989) has studied how preoperational children manipulate the turtle on the computer screen. The results of her study demonstrates that these children are operating from an egocentric perspective, using their bodies as a guide to determine the direction the turtle should go. Once this has been determined the children point the turtle in that desired direction and then move it. Hart and Moore (1973), cite research supporting this explanation, and state that the direction to a place is ""represented in the mind" in terms of movement of the body through turning the head or pointing, both of which bring us into alignment with the place" (p. 275). From this initial pointing behavior, later on-screen spatial development seems to occur.

Fay and Mayer (1987) researched the naive conceptions and confusions children demonstrate while executing LOGO commands. Generally, they found that younger students had more difficulty with commands than older children (grades four to eight), and that FORWARD commands were easier for the children than were all other commands. Fay and Mayer reported that BACK was easier than either LEFT or RIGHT. They further demonstrated that the initial orientation of the turtle was significant for its movement. Student performance decreased when the turtle's orientation was rotated 180 degrees and increased when the orientation was 0 degrees (up-right position). Similar findings were reported by Gallini (1987).

Campbell, Fein, Scholnick, Schwartz, and Frank (1986) reported that kindergarten children could use forward moves more accurately than either backward or left moves, and that right turns were favored over left turns. Campbell, et. al. (1986) suggest that these movements demonstrate a "grid" or "rectangular coordinate system" (p. 359). The "grid" system implies that the child uses only right angle (90 degree) turns and the movements foward/backwards and right/left. They further noted that some subjects were able to move on a diagonal and hypothesized that these movements occur when the child no longer perceives the computer screen as being made up of a pattern of grids, but has come to view the screen as a system of concentric circles extending out from the cursor creating a "polar coordinate system" (p. 360). They further stated that with the "polar coordinate system" the child no longer has to move the cursor forward and at right angles along a grid, but may now turn the turtle to any angle of rotation and move either forward or backward.

This allows the child maximum flexibility of cursor movement through complementary reciprocal distance and direction commands.

<u>Age</u>

Papert, the developer of LOGO, based this program on the developmental theory of Piaget. Piaget divided development into four fixed and immutable stages. These are the sensorimotor (0-18 months); preoperational (18 months-7 years); concrete operations (7 years-12 years); and formal operations (12 years plus) (Mussen, Conger, Kage, & Huston, 1984). This study will focus on the preoperational and concrete operations stages of development. The preoperational stage is characterized by the child using symbols, including words, exhibiting a lack of understanding of the principle of conservation, and operating from an egocentric perspective (Mussen, et al, 1984). As children move through this stage their language becomes less idiosyncratic and more conventional. While their words have the appearance of intelligence and seem to mean about the same as an adult's, there still exists a wide gap and communication between can break down.

The second characteristic of this stage is the lack of "conservation". "Conservation" in this sense refers to the child's ability to recognize that when some dimension of a substance is altered this amount is "conserved," still present, as long as nothing is added or taken away (Rohwer, Ammon, & Cramer, 1974). The preoperational child is unable to recognize or apply this principle.

Related to the above is the fact that preoperational children generally focus on one aspect of the situation to which they are responding. For example, as the dimensions of a substance change the child's attention would be on only one change and not the others. This is true of the personal relationships of the preoperational child as well. Within this framework the child is unable to perceive things from another's perspective. The child is operating egocentric manner. Towards the end of this stage, while approaching that of "concrete operations", the child "evidences representional thought and is less egocentric, but is [still] unable to perform most problems involving the conservation of number, mass, area, weight and volume (Howell, Scott, & Diamond, 1987, p. 250)."

Mussen, et al., (1984) place entry into the concrete operations stage as occurring between the ages of 6 and 8, while Rohwer, Ammon, & Cramer (1974) place it at age 7. During this stage the child approaches problems with a kind of logic that was missing before. This ability is helped by the development of structures (coordinated mental actions) that permit decentration and reversibility (Rohwer, et al, 1974). The child can now respond logically to problems of conservation focusing on more than one aspect at a time.

However, these responses are still limited to actual problems, not hypothetical ones. Based on the Piagetian theory, the subjects of this study are operating within the following stages: 7 year olds (second graders) are operating from a transitional stage between preoperational and concrete operations, and 10 year olds (fifth graders) from within the concrete operations stage.

Instructional environment

There is an impressive array of results concerning LOGO training and instructional approaches, especially those approaches which employ metacognitive strategies (Clements & Gullo, 1984; Miller & Emihovich, 1986; Solomon & Perkins, 1987; Watson, Brinkley, Ingles, Howard, Sheets, Hatfield, Myrick, Proia, & Penny, 1988). Miller and Emihovich (1986) and Myrick, et al. (1987) utilizing "mediated instruction" (teacher/child activities which stress "the big picture"---top-down thinking) and/or "scaffolding" (activities which support the children's "bottom-up" thinking). "Comprehension monitoring" (eliciting comprehension information from children by asking them to (a) plan what needs to be done, (b) give "next steps", (c) evaluate work, and (d) "debug" any mistakes) is a third type of metacognitive strategy.

Markman (1981), an early researcher into the benefits of comprehension monitoring for reading instruction, cited well-documented research showing that children often do not realize that they do not understand something. Markman stated that children "may tend to evaluate their comprehension of such prose in a piecemeal fashion, focusing on component sentences, but not attempting to use a criterion that requires imposing a higher order organization on the material" (p. 67). She suggested that comprehension monitoring can be improved through the "systematization of knowledge". This "systemization" includes (1) uniting separate facts into higher structures; (2) generating expectations and providing opportunities to confirm or refute them; and (3) gaining knowledge about the structures of various tasks to guide inferences and hypothesis testing.

Miller and Emihovich (1986), extending the work begun by Clements and Gullo (1984), evaluated the effectiveness of comprehension monitoring with pre-school children in both LOGO and computer assisted instruction (CAI). Gallini (1987) conducted a similar study involving fourth graders. Both Miller & Emihovich and Gallini found significant increases in monitoring skills for the LOGO group while control subjects showed no improvement. These studies, although encouraging, are inconclusive because, as Miller and Emihovich write, "mediated instructional practices may be best applied in learning contexts where a wide range of alternatives exist for task solutions and where problem solving is required" (p. 288). Gallini suggests that LOGO programming, as opposed to CAI, supports this process of "reflective thinking".

Cognitive Styles

The environment in which the computer is used is important for intellectual development, but so is the individual's cognitive style. Smith (1984-1985) stressed that when meeting the needs of students, educators need to recognize their styles and strategies. Kogan (1973) defines cognitive style as an "individual variation in modes of perceiving, remembering . . ." (p. 160).

Many dimensions of cognitive style have been identified, but the differences between the field dependent and the field independent (FD-FI) have received the most study. Field dependent persons rely on an external frame of reference when processing information, and are more "people oriented"; responding to what people say and do. Field independent persons, on the other hand, rely more on an internal frame of reference when processing information, and also demonstrate greater cognitive restructuring on cognitive and perceptual tasks (Witkin, Moore, Goodenough, and Cox, 1977). Garringer and Frank (1986) write that "field independent students [are] more likely to use a hypothesis-testing approach to problem solving, and field dependent students [are] more likely to display passive, spectator-like strategy to acquire information (p. 2)."

Saracho and Spodek (1981) add that field dependent individuals also respond to the "context" in which they are working as a whole, without reflecting on or analyzing the situation. These individuals conform to the existing field. In contrast, field independent individuals are able to separate the "context" into its component parts, reflecting upon and/or analyzing the situation, as well as, being able to go beyond the existing field. Differences in these strategies are important to an understanding of the manner in which the individual solves problems.

Theoretical Model

This research draws from the theory/constructs of Papert (1980), Siegel (1975), Emihovich and Miller (1987), and Kogan (1983). From Papert comes the syntonic learning construct. Syntonic learning is learning which is compatible or meaningful to each person's sense of life or their internal/external life situations (analogous to learning in relation to the child's body). The study will create a LOGO problem-solving environment in which the "turtle" becomes an "object with which to think," allowing the subjects to express abstract (internal) ideas and thoughts externally, through movements (up-down, right-left) on the screen. Siegel's theory of spatial development is a second component of this model. His constructs of landmarks, routes, and configurations provide a framework from which to understand how children navigate within the small-scale environment of the computer screen. These computer "environments" are "abstract and presented in a vertical/horizontal plane parallel to the child's body (placement of microcomputer screen)" (Watson, et. al., 1987-1988, p. 6). This presentation makes the child mentally rotate objects, which are generally up-right in a real-world context, to perspective as seen from above (as well as up-right on the computer screen).

Finally, the components of stylistic differences (Kogan) and comprehension monitoring (Emihovich and Miller) complete the model. The subject's preferred styles of learning (field independent versus field dependent) is used to test whether the student's stylistic preference produced differential effects and if so, are these differences consistent between groups. Comprehension Monitoring is used to elicit information relating to a given task (planning the task, determining "next steps", debugging mistakes, and evaluating completed work).

CHAPTER III

METHODS AND PROCEDURES

Subjects

Eighty students enrolled in the Alamance County School System, Alamance County, North Carolina (forty each from the second and fifth grades) were the subjects. These students were chosen at random from two schools within the district. Letters describing the study were sent home a week before the study began (see Appendix 1); completed forms were collected by the experimenter. Only subjects whose caretakers approved were included in the study. One subject had to be replaced because his caretakers said that he could not participate in the study. The replacement was chosen at random.

Design

The research design is a counterbalanced, 2 X 2 X 4 repeated-measures ANOVA for problem-solving and a MANOVA for comprehension monitoring. Tabachnick and Fidell (1983) and Keppel (1982) write that repeated measures ANOVA (within-subjects ANOVA) is a useful tool to use when the same variable is measured on several occasions for each subject. Because several measurements are taken for the same subjects a smaller error term is produced. This is due to reduced individual variability, and allows for greater sensitivity when testing the independent variables.

Hair, Anderson, Tatham, & Grablowsky (1979, p. 161) write that MANOVA is useful "because it permits the simultaneous testing of all variables, [and] accounts for any correlation among the variables . . . ." The MANOVA analysis also guards against Type 1 errors that can occur in analyzing a series of ANOVAs.

Independent Variables. There were three categories: (1) cognitive style (either field dependent or field independent), (2) developmental variables (second and fifth grades) (3) twelve problem-solving tasks (these being three patterns to be replicated, each in four positions).

Dependent Variables. There were two categories: problem-solving and comprehension monitoring. Discrete measures for problem-solving (pattern replication) included (A) time for partial task completion and (B) total number of keystrokes (turns, steps, and errors). Discrete measures for comprehension monitoring include (a) "hypothesis generation" scores (b) "planning ahead" scores (c) "comparing alternatives" scores (d) "evaluating outcomes" scores and (e) total score on the Comprehension Monitoring Score Sheet (Myrick, et al., 1987).

Time for partial task completion was operationally defined as the time it takes the subject to complete one-half of the problem-solving task. For treatment levels, time for partial task completion was operationally defined as the mean time for the total of the times of all subjects assigned to the treatment group. For either individual or treatment measures, the least amount of time taken to complete a task was considered the most efficient.

The discrete measures of commands (turns, steps and errors) were operationally defined, a priori, by evaluating the pattern of each problem-solving task card, and determining what manipulations best reproduce the selected patterns. These were used as a "yardstick" from which to measure errors (inappropriate manipulations determined a priori).

Discrete measures of "hypothesis generation" were operationally defined as the score the individual receives on question 1 of the Comprehension Monitoring Score Sheet (CMSS) (see Appendix 2). Discrete measures of "planning ahead" were operationally defined as the score the individual receives on question 2 of the CMSS. Discrete measures of "comparing alternatives" were operationally defined as the score the individual receives on question 3 of the CMSS. Discrete measures of "evaluating outcomes" were operationally defined as the score the individual receives on question 4 of the CMSS. Total score for comprehension monitoring was operationally defined as the total score on all sixteen CMSS questions.

Testing

Children's Embedded Figures Test: A standardized individually administered perceptual disembedding test for measuring FI-FD cognitive styles (Karp & Konstadt, 1971) was used for testing subjects participating in this study. Scores, divided by a median split, categorized half the subjects as field dependent and the other half as field independent. The CEFT was designed for use with children between the ages of 5 and 12, and reliability estimates range from .83 to .90 dpending upon grade level (Karp & Konstadt, 1971).

The use of the median split has one disadvantage: those who score just above or below the median might conceivably fall into the alternate grouping category if tested at a different sitting.

Equipment

The equipment used in this study was an Apple IIe computer with Apple monitor, along with Apple LOGO II software (Logo Computer Systems Inc., 1984).

Trainer/Observer

The experimenter served as the trainer/observer (T/O) for this study and was responsible for setting up the equipment, the software, training the subjects on the commands selected for this study and in the comprehension monitoring model used, and scored all score sheets.

A standard score sheet was used to record the dependent measures of problem solving (see Appendix 3). The T/O recorded the commands made. This record contained the number of keystrokes made, as well as the direction and distance of each movement. The T/O also recorded the time it took the subject to complete one-half of the pattern as well as the time it took to complete the whole pattern (up to the 3 minute 50 second time limit). Data relevant to the study were recorded during the time the subject and the T/O were together. These measures have been used in studies focusing on children's mastery of LOGO and their manipulation of the "turtle" (Campbell et al., 1986; Watson, et al. (1987)).

Comprehension monitoring measures were recorded by the T/O on the Comprehension Monitoring Score Sheet (Myrick, et al., 1987). This instrument was scored and recorded after the subject had been asked at least two questions from each of four comprehension monitoring categories and had completed the problem-solving task cards.

Procedures

Data collection. All training and the data collection were conducted on an individual basis. The CEFT, problem-solving, and comprehension monitoring data were collected Mondays through Thursdays for the study between 8:30 and 3:00 within the schools.

Commands The following commands were taught to the subjects participating in this study: Forward (FD 10 and FD 20); Right Turn (RT 90 and RT 45); Backward (BK 10 and BK 20); and Left Turn (LT 90 and LT 45). Also, students were taught use of the space bar, delete key, and return key

The trainer observer (T/O) was also familiar with the following: Control-T (allows the T/O to accurately review all commands). Control-S (returns the screen to the turtle after review) and Control-L (allows the T/O to extend the viewing area to the bottom of the screen, removing from view all typed commands. "CS" returns the turtle to its "home" position (in the middle of the screen pointing upwards), "ST" makes the turtle appear on the screen, and "HT" hides the turtle from view. The turtle is brought back into view with the command "ST".

Training

All subjects involved in this study received five training sessions with the computer, and its key commands (FD 10, FD 20; BK 10 BK 20; LT 45, LT 90; RT 45, RT 90, Delete, and Return), and the comprehension monitoring model (Miller, 1985). During each session the T/O introduced the subjects to three commands. The subjects then practiced them (See sample lesson Appendix 5). In session 1, the subjects drew a square using the first three commands (FD 10, FD 20, RT 90, and Return) (See Appendix 6 figure 1). During the second session the subjects learned three additional commands (RT 45, BK 10, and BK 20) and learned to draw a right triangle (See Appendix 6 figure 2). In the third session the commands LT 90 and LT 45 were introduced and subjects were asked to draw double squares (See Appendix 6 figure 3). They were also shown the key command poster which explained the function of each key command and showed it pictorially. In the fourth session (a practice session) the formal introduction of the comprehension monitoring model occurred. During the fifth session, subjects were asked to describe what each key and command would do and then to demonstrate it. The T/O recorded whether each subject could describe commands and execute them on-screen. Following this brief review subjects completed four problem-solving task cards (See Appendix 7), each containing a figure that had been rotated in one of four orientations (the upper right-0 degree, the lower right-90 degree, the lower left-180 degree, and the upper left-270 degree). As the subject completed each card, the T/O recorded the time taken to complete one-half the pattern and then the entire pattern (up to 3 minutes 50 seconds). The number of commands used (including all turns, steps and errors) was also recorded at this time.

After each task card had been solved the subject was asked two comprehension monitoring questions (See Appendix 4). At the end of this session the Comprehension Monitoring Score Sheet was scored. Subjects had to have successfully replicated at least two of the four patterns within the time limit and scored 35 or better on the Comprehension Monitoring Score Sheet to go to the sixth session. Subjects who did not achieve these scores were dropped from the study. All subjects met these requirements and none were dropped from the study.

During session 6, 7, and 8, subjects replicated card sets 1, 2, and 3 (See Appendix 8, 9, and 10), and the procedures used in session 5 were repeated.

Comprehension Monitoring Model

During this training period subjects were also instructed in the comprehension monitoring model employed by Miller (1985). This model involved instructing subjects in five self-statements (taught using a four phase fading procedure). These statements were used to develop comprehension monitoring skills and are as follows:

> Problem Definition: First, I am going to have to decide what I must do (complete this task card on the computer screen).
>
> Problem Approach: Second, as I look at this task I will ask myself "What will I have to do (tell the computer to do) to complete this? (This statement is related to "hypothesis generation" and the "planning ahead" questions of the Comprehension Monitoring Score Sheet.)
>
> Evaluate approach: Third, I will now make two or three moves (on the computer screen) and ask myself if they look right (This statement is related to the "compares alternatives" questions on the score sheet.

Self-reinforcement: Fourth, when I have completed these moves I will see if I have made any mistakes (errors). After correcting these, or deciding that I have none, I will tell myself that I am doing a great job.

Task completion: Fifth, if I have not completed this task I will complete it. If I have completed the task, I will ask myself what mistakes I made, if any, and what I learned about them that could help me next time (This statement is related to the "evaluating outcomes" question on the score sheet).

A four phase fading procedure was used to teach the above five self-statements:

Phase 1: The T/O models the instructional self-statements for the subject as the task is demonstrated.

Phase 2: The T/O and the subject verbalize the self-statements while working together on the task.

Phase 3: The subject whispers the statements alone as he/she works on the problem-solving tasks.

Phase 4: The subject repeats the statements silently. During this phase the subject points to the number (1-5) of the statement they are using.

This gives the T/O an idea of what the subject is thinking. Once this phase had been introduced, subjects were encouraged to use these self-statements on all the problem-solving tasks.

This instruction also involved the T/O asking questions designed to develop these skills (see Appendix 4). This technique was used during sessions 1 through 4. How well the students employed the model was measured during sessions 5 through 8. Comprehension monitoring has been demonstrated by researchers (Emihovich & Miller, 1986; Watson, et al., 1988; Myrick, Procia, Hatfield, & Watson, 1987; Markman, 1981) to be an effective strategy for the development of the skills being taught. Each session that followed ended with the above comprehension monitoring activities.

Problem-solving exercise

The first set of cards was presented in the sixth session. A counterbalanced (varied) sequence of card presentation was used to control for treatment order effects.

Task cards. These were twelve 5 X 8 cards which contained the patterns to be replicated. This pattern appeared within the appropriate quadrant in which it was to be replicated. Each card contained one of three patterns that increased in difficulty and required the subject to (a) work in one quadrant, or (b) work in all four quadrants. Patterns required (1) 90 degree turns and movements, (2) a combination of 45 degree and 90 degree turns and movements, (3) 45 degree turns and movements only. Each pattern was rotated 0 degrees (the upper right), 90 degrees (the lower right), 180 degrees (the lower left), and 270 degrees (the lower right) (see Appendix 7, 8, 9, 10). Each problem-solving task began with a cleared screen (the CS command); the turtle in the middle of the screen pointing upwards. From this position the subject had to point the turtle in the proper direction and proceed.

Task cards were displayed in clear view beside the monitor's screen. Subjects worked on one task card at a time. Four cards were given per testing session, and subjects would have 3 minutes 50 seconds to complete a card. The T/O began timing as soon as the instructions had been given. If the subject had not completed the task at the end of the time period, the observer told the subject that he/she had done a good job on the task, but that now it was time to try another card. The keystrokes that were made were used in computing the replication score. If a subject had not begun a task within one minute the observer encouraged him/her to begin, and after two minutes if the subject had not begun the observer told him/her that it was "ok", and said, "let's try another". Each task card was completed (or terminated) before continuing on to the next problem-solving task. It was important to keep the assessment times as brief as possible to avoid the confounding problem of fatigue and inattention/motivation.

During the task the T/O asked the subject at least two comprehension monitoring questions and recorded the answers. These provided the T/O with an indication of the subject's comprehension monitoring. At the end of each session the Comprehension Monitoring Score Sheet was scored.

Scoring of Exercises Training and Problem-solving exercises were scored based on an a priori determination of movements needed to complete the card. These a priori determinations take into consideration the different perspectives the subject may adopt concerning problem-solving. Errors were determined based on these movements (See Appendix 11, 12, 13, 14).

Errors. Errors were determined as follows: (1) Inappropriately typed commands (keystrokes) (letters/numbers left out, return pressed too early, etc.) (2) Incorrect commands typed (going left instead of right, if the subject (a) acknowledges a mistake or (b) goes in the first direction and then reverses) Both the command in error and the corrective command were counted as incorrect. If a student did not react, nor correct the command, this would not be counted as an error---there are different ways to solve the same problems. (3) When distance and turn keystrokes were confused (FD 90 instead of FD 10) the keystroke in error and the corrective command were both counted as errors. (4) Extra keystrokes that were obviously inappropriate (such as too many forward commands). This would not include using two 45 degree turn commands to make a 90 degree turn, or moving Forward/Backward 10 twice to make a Forward/Backward 20 move. While not necessarily efficient, these were not considered inappropriate or in error, but as particular keystroke preferences. (5) All keystrokes made in replicating a problem-solving task when it was replicated in an inappropriate quadrant.

Instructions to subjects. The subjects were instructed that the cursor (turtle) was like a spaceship carrying rocket scientists and students like themselves to the moon. Sometimes, the scientists have navigational problems and forget the correct path to take. This is one of those times, and the scientists need some help. The subjects were then told that they would be shown some cards which pictured the paths these scientists needed to know. The subjects were told that when they were shown these cards they were to guide the ship (turtle) on the path pictured. They were told they were to take the exact path shown (so as to avoid meteors) and that this exact path would get them to the moon as quickly as possible. Each subject was then asked if they had any questions, and before they began to complete the problem-solving task, the T/O instructed him/her to do his/her best. As the subjects worked on the patterns the observer used terms like "great", "super", "terrific", "keep up the good work", etc.

Data Analysis

Data were analysed using a 2 X 2 X 4 repeated- measures ANOVA for problem-solving and a MANOVA for comprehension monitoring. The problem-solving analysis tested for within-subject differences (partial time for task completion and total number of keystrokes used to complete one-half of the problem-solving task) as well as between-subject differences (cognitive styles and grade levels for the quadrants problem-solved) and any interaction effects of these variables. The special contrasts available for use with this method of analysis were used to evaluate the relationships that existed between pairs of scores, both within a group and between groups. The MANOVA tested for any main effects and interactions that may have been present, and Tukey's method of multiple comparisons was also used to determine the relationships that may have existed between groups of scores for comprehension monitoring.

CHAPTER IV

RESULTS

Findings from the present study related to the hypotheses are reported in this chapter. First, data are generally discussed in relation to the response distribution and statistical assumptions. Next, each hypothesis is stated and the results contributing to its confirmation or disconfirmation are given. Finally, the chapter concludes with a summary of results.

Statistical Assumptions

The basic statistical assumptions for repeated measures ANOVA and MANOVA are the same as for ANOVA which are: that the sample be drawn at random, and that the independent measures be normally distributed and have equal variances at each point where dependent measures are taken (Hair, et al.,1979). The validity of the F test for significance is strengthened when the above assumptions are met. Hair, et al. (1979) and Tabachnick and Filell (1983) write that the F test is a robust statistic that resists minor violations of the above assumptions.

The subject sample selected was conducted at random and included random selection of the school system, the schools within that school system, and the students within each school. A direct examination of the scatterplot of residuals indicated a general linearity with few "outliers" or deviant cases, thereby meeting that ANOVA assumption. The analyses were conducted leaving the outliers in. A visual scanning of error components showed them to generally have a mean of zero and about the same variance over the ranges of values for the dependent measures. As a result of these observations, it was concluded that the ANOVA statistical assumptions were met by the data.

Data from Hypotheses 1 and 2 were tested using repeated measures ANOVAs and the special contrasts this method allows. These special contrasts allowed for the direct examination of variables for a given problem- solving task with specific groups of subjects. These comparisons were made both within a group of subjects (comparing second grade field dependent students on the different rotations of the problem solving task) and between different groups of subjects (comparing second grade field dependent students with second grade field independent students or fifth grade field dependent/field independent students). Data for Hypotheses 3 were tested first using a MANOVA analysis in order to determine significant main effects and interactions. Next, pairwise comparisons were analyzed using Tukey's (HSD) comparisons in order to determine significant differences within and between groups.

Background Information

Two 2 X 2 X 4 repeated measures ANOVAs (Kepple, 1982) were used to test for significant differences between grade level (2), cognitive style (2) and pattern rotations for card sets (4). The analysis first involved using only the measures of total number of commands (Strokes) and partial time for task completion (Time) used to complete one-half of a problem-solving task.

Results of the repeated measures ANOVA testing for within subjects and between subjects effects revealed the following information:

Card Set 1 (CS1). CS1 required the subject to replicate a problem-solving task that involved using 90 degree turns only. These tasks were considered to be the easiest level to complete. Concerning strokes, the unweighted means analysis (Type III) for between- subject effects showed a main effect for Grade Level [F (1, 65) = 58.86, p = .0001]. An interaction between Grade Level and Cognitive Style showed no significance [F (1, 65) = 3.54, p = .0643]. The analysis for within-subject effects showed a main effect for Strokes [F (3, 195) = 22.83, p = .0001] and interactions for Strokes and Grade Level [F (3, 195) = 4.33, p = .0055] (no tables presented).

The analysis for Time for CS1 between-subject effects (unweighted means analysis Type III) revealed that there were main effects for Grade Level [F (1, 195) = 58.86, p = .0001] and Cognitive Style [F (1, 65) = 4.08, p = .0475]. There was no significance for an interaction between Cognitive Style and Grade Level [F (1, 65) = 3.54, p =

.0643]. Within-subject effects demonstrated that there were main effects for Time [F (3, 195) = 11.30, p = .0001] and an interaction effect for Time and Grade Level [F (3, 195) = 2.83, p = .0410] (no tables presented).

<u>Card Set 2 (CS2).</u> CS2 required the subject to complete problem-solving tasks that involved both 90 degree and 45 degree turns. These tasks were considered to be mid-level in difficulty to complete. Concerning Strokes, the between-subject effects analysis (unweighted means Type III) revealed a main effect for Cognitive Style [F (1, 60) = 20.07, p = .0166]. Within-subject effects showed a main effect for Strokes [F (3, 180) = 9.29, p = .0001] and an interaction effect for Strokes and Cognitive Style and Grade Level [F (3, 180) = 5.66, p = .0001] (no tables presented).

Between-subject effects for Time (unweighted means analysis Type III) revealed main effects for Grade [F (1, 60) = 47.96, p = .0001] and Cognitive Style [F (3, 60) = 5.37, p = .0384] and an interaction effect for Grade and Cognitive Style [F (3, 60) = 5.37, p = .0239]. Within-subject effects showed a main effect for Time [F (3, 180) = 13.69, p = .0001] and interaction effects for Time and Grade [F (3, 180) = 5.03, p = .0023] and Time and Cognitive Style and Grade Level [F (3, 180) = 3.75, p = .0121] (no tables presented).

<u>Card Set 3 (CS3).</u> CS3 required that the subject complete problem-solving tasks requiring 45 degree turns

only. These tasks were considered to have the greatest level of difficulty for problem-solving. Concerning Strokes the between-subject effects (unweighted means analysis Type III) demonstrated no significant differences. Within-subject effects, however, revealed main effects for Strokes [F (3, 138) = 3.30, p = .0263] and an interaction effect for Strokes and Grade Level [F (3, 138) = 5.09, p = .0032] (no tables presented).

The analysis for Time (unweighted means analysis Type III) revealed a between-subject main effect for Grade Level [F (1, 46) = 32.67, p = .0001]. Within- subject effects showed a main effect for Time [F (3, 138) = 3.21, p = .0250]. Also revealed in this analysis were interaction effects for Time and Grade Level [F (3, 138) = 4.55, p = .0045] and Time and Cognitive Style [F (3, 138) = 2.67, p = .0499] (no tables presented).

Next, an analysis was conducted using the comprehension monitoring measures (CMTotal (CMTOT), CM1, CM2, CM3, and CM4). The design called for the experimenter to complete the Comprehension Monitoring Score Sheet (CMSS) on each subject for each card set. After looking at the results of each score sheet, it was noted that the subject's scores did not vary from card set to card set. The CMSS required the experimenter to rate each subject's understanding for the first four comprehension monitoring questions, and then the subject's interactions with the experimenter and within the problem-solving environment. The subjects responses to the first four questions did not change to any significant degree from card set to card set. Their understanding of what was being required of them remained the same. It was the subject's translation of these understandings into action, in order to complete the problem-solving tasks, that differed from card set to card set. The interactions between the experimenter and the subjects also did not change over the three day period on which Card Sets 1, 2, and 3 were completed; therefore, the scores after the first four comprehension monitoring questions did not change. Because the scores were the same for each card set, the analysis for Hypothesis 3 which is concerned with subject's comprehension monitoring used only one set of scores from which the results are based (Card Set 1).

Results of the MANOVA conducted revealed main effects for Cognitive Style [F (5, 308) = 13.87, p = .0001] and Grade Level [F (5, 308) = 9.94, p = .0001]. The analysis also revealed an interaction effect for Cognitive Style and Grade Level [F (5, 308) = 6.55, p = .0001] (no tables presented).

Individual tests of comprehension monitoring variables revealed the following information. For CM Total there was a main effect for Grade Level [F (1, 316) = 21.32, p = .0001] and an interaction between Cognitive Style and Grade

Level [F (1, 316) = 4.10, p = .0438]. For CM1 there were main effects for Cognitive Style [F (1, 312) = 17.76, p = .0001] and Grade Level [F (1, 312) = 8.13, p = .0046]. There was also an interaction for Cognitive Style and Grade Level [F (1, 312) = 13.22, p = .0003]. For CM2 there was only a main effect for Grade Level [F (1, 312) = 37.98, p = .0001]. For CM3 there were main effects for Cognitive Style [F (1,312) = 12.21, p = .0005] and Grade Level [F (1, 312) = 37.79, p = .0001]. Finally, for CM4 there was a main effect for Grade Level [F (1, 312) = 21.71, p = .0001] and an interaction for Cognitive Style and Grade Level [F (1, 312) = 11.65, p = .0007] (no tables presented). Because the study was concerned with the differences that existed between groups, the results are based on Tukey's comparisons. These comparisons are reported in a table format and this table also includes the magnitude and direction of the differences found (see Table 5.

While not specifically investigated, but of general interest, special contrasts for Errors revealed that Errors were significant only for Card Set 1 (90 degree turns only) and not for the other two card sets (Card Set 2 (90 and 45 degree turns) and Card Set 3 (45 degree turns only)). For Card Set 1 these errors were significant for all rotations for 2FI and 2FD subjects when compared with 5FI subjects, with the second graders having more errors than the fifth graders. 2FD subjects differed with 5FD subjects on the

Table 1

The Results of Special Contrasts for Repeated Measures ANOVA for Errors for Card Set 1 *

Contrast	Difference	DF	SS	F	PR>F
0 2FI v 0 5FI	2.0	1	37.45	12.29	.0006
90 2FI v 90 5FI	1.4	1	19.03	6.24	.0132
180 2FI v 180 5FI	2.5	1	56.17	18.43	.0001
270 2FI v 270 5FI	1.9	1	31.74	10.41	.0015
90 2FD v 90 5FD	1.8	1	29.68	9.74	.0021
180 2FD v 180 5FD	1.6	1	24.75	8.12	.0048
270 2FD v 270 5FD	1.4	1	17.43	5.72	.0177
0 2FD v 0 5FI	1.3	1	16.73	5.49	.0201
90 2FD v 90 5FI	2.5	1	56.98	18.69	.0001
180 2FD v 180 5FI	3.1	1	95.23	31.24	.0001
270 2FD v 270 5FI	2.6	1	61.22	20.08	.0001
180 5FI v 180 5FD	-1.5	1	20.68	6.78	.0098
270 5FI v 270 5FD	-1.2	1	13.92	4.57	.0331

* Special contrasts for Card Set 2 and Card Set 3 were not significant.

lower right, lower left, and upper left quadrants with the second graders making more errors than the fifth graders. Finally, 5FI subjects differed significantly from 5FD subjects on lower left and upper left quadrant tasks. For these rotations 5FI made fewer errors than did the 5FD subjects (See Table 1).

The above results are presented to indicate the nature of the main effects and interactions found. Because this study is interested in looking at differences within a group of subjects and between these groups, data analysis of pairwise means (special contrasts for repeated measures) will be hereafter reported. These special contrasts will be reported in a table format that includes the F statistics and degrees of freedom, as well as the magnitude and direction of the differences found (see Tables 1, 2, 3, and 4). Information about errors is given to indicate the relationship between errors and total keystrokes.

<u>Analysis of Data</u>

<u>Hypothesis 1.</u>

H1 There will be a significant pattern rotation (quadrant) effect found within subjects based on cognitive style and grade level as measured by partial time for task completion and total number of commands used to complete one-half of the task.

(A) Subjects replicating the pattern

in the upper right quadrant (0 degree rotation) will do significantly better as measured by taking less time and using fewer commands to replicate one-half the problem-solving task.

The hypotheses contained in this section are limited to comparing subject performance for the upper right quadrant (the hypothesized least difficult quadrant) as it compared specifically with the other three quadrants. Specific comparisons for the lower right and specific comparisons for the upper left quadrants were not calculated. Special contrast for repeated measures ANOVA for Card Sets 1, 2, and 3 comparing the upper right quadrant tasks (0 degree rotation) with the lower right quadrant tasks (90 degree rotation), lower left quadrant tasks (180 degree rotation), and upper left quadrant tasks (270 degree rotations) within each group supported the hypothesis.

<u>Card Set 1</u>

For Card Set 1 (the least difficult card set) the 2FD, 2FI, 5FD used more strokes to complete the lower right quadrant task than they did the upper right task, and all groups took longer to complete the lower right quadrant task than the upper right. 2FD also used more strokes and took longer to complete the lower left quadrant task than they did the upper right quadrant problems (see Table 2).

Table 2

The Results of Special Contrasts for Repeated Measures ANOVA for Upper Right (0 degree) Comparisons for Card Sets 1, 2 and 3

Results for Card Set 1

Strokes

Contrast	Difference	DF	SS	F	PR>F
0 v 90 2FD	-3.2	1	99.73	32.21	.0001
0 v 180 2FD	-1.8	1	30.63	9.89	.0019
0 v 90 2FI	-1.1	1	11.61	3.75	.0542
0 v 180 2FI	1.5	1	20.63	6.66	.0105
0 v 90 5FD	-1.6	1	12.30	3.97	.0476
0 v 180 5FD	1.8	1	13.61	4.90	.0372

Time

Contrast	Difference	DF	SS	F	PR>F
0 v 90 2FI	-18.3	1	3330.61	4.32	.0390
0 v 90 2FD	-52.8	1	26910.03	34.87	.0001
0 v 90 5FI	-20.1	1	3820.03	4.95	.0271
0 v 90 5FD	-31.9	1	4772.98	6.18	.0137

Results for Card Set 2

Strokes

Contrast	Difference	DF	SS	F	PR>F
0 v 90 2FD	-1.8	1	31.57	5.96	.0154
0 v 180 2FD	-2.1	1	37.81	7.14	.0081
0 v 180 5FD	2.3	1	23.86	4.51	.0349
0 v 270 5FD	-2.2	1	22.80	4.31	.0392

Table 2 (continued)

Time

Contrast	Difference	DF	SS	F	PR>F
0 v 180 2FI	-26.5	1	6514.27	7.64	.0062
0 v 270 2FI	-40.4	1	14649.58	17.18	.0001
0 v 180 2FD	-48.9	1	20726.28	24.31	.0001
0 v 270 2FD	-23.7	1	4838.44	5.67	.0181
0 v 270 5FD	-50.7	1	11757.85	13.79	.0003

Results for Card Set 3
Strokes

Contrast	Difference	DF	SS	F	PR>F
0 v 90 2FI	5.0	1	135.01	12.09	.0006
0 v 180 2FI	3.0	1	50.79	4.55	.0344
0 v 90 2FD	2.9	1	48.15	4.31	.0394
0 v 270 2FD	-2.7	1	46.76	4.19	.0423
0 v 90 5FI	2.1	1	40.70	3.65	.0579
0 v 90 5FD	7.1	1	170.23	15.25	.0001

Time

Contrast	Difference	DF	SS	F	PR>F
0 v 90 2FI	41.6	1	9403.46	9.32	.0026
0 v 180 2FI	52.9	1	15347.03	15.21	.0001
0 v 90 2FD	25.4	1	3928.11	3.89	.0501
0 v 90 5FD	42.3	1	6113.67	6.06	.0148
0 v 180 5FD	37.3	1	4839.53	4.80	.0299

Card Set 2

For Card Set 2 (the mid-level of difficulty card set), 2FD subjects used more strokes to complete the lower right and lower left quadrant tasks than they did to complete the upper right quadrant task. Both 2FD and 2FI subjects took longer to complete the lower left and upper left quadrant tasks than they did the upper right. 5FD subjects used more strokes and took longer to complete the upper left than the upper right (see Table 2).

Card Set 3

For Card Set 3 (the most difficult level of card set) the hypothesis was not supported. In fact the opposite of the hypothesis was true. Second grade field independent (2FI), 2FD, and 5FD subjects used more strokes and took more time to complete the upper right rotation than they did the lower right rotation.

5FI subjects also used more strokes to complete the upper right rotation than they did the lower right, but did not differ on time. 2FI and 5FD subjects took less time to complete the lower left rotation than they did the upper right (See Table 2).

(B) Subjects replicating the pattern in the lower left quadrant (180 degree rotation) will do significantly poorer as measured by taking more time and using more strokes to replicate one-half the pattern.

The hypothesis contained in this section are limited to comparing suject performance in the lower left quadrant (the hypothesized most difficult) as it compared specifically with the other three quadrants. Special contrasts for repeated measures ANOVA, comparing the lower left quadrant tasks with the upper right (0 degree rotations), the lower right (90 degree rotations), and the upper left (270 degree rotations) generally supported this hypothesis but only for second graders. There were no significant differences for fifth graders for neither strokes nor times for the lower left quadrant problems.

<u>Card Set 1</u>

For Card Set 1 the upper left rotation was the only rotation that differed from the lower left for both 2FI and 2FD subjects. Each of these groups used significantly more strokes to complete the lower left rotation than the upper left, and for 2FD subjects the lower left rotation took more time to complete than the upper left. Finally, 2FD subjects used more strokes to complete the lower right quadrant task than the lower left (see Table 3).

<u>Card Set 2</u>

For Card Set 2 the hypothesis was not supported for strokes, but was supported for time. For 2FI subjects the upper right rotation took significantly

Table 3

The Results of Special Contrasts for Repeated Measures ANOVA for Lower Left Quadrant (180 degree) Comparisons for Card Sets 1, 2, and 3

Results for Card Set 1

Strokes

Contrast	Difference	DF	SS	F	PR>F
180 v 90 2FI	-1.45	1	19.45	6.28	.0130
180 v 270 2FI	1.20	1	11.70	3.78	.0532
180 v 90 2FD	1.50	1	20.70	6.68	.0104
180 v 270 2FD	1.60	1	24.96	8.06	.0050
180 v 90 5FI	-2.60	1	63.18	20.41	.0001
180 v 0 5FI	-1.50	1	20.63	6.66	.0105
180 270 5FI	-1.60	1	23.68	7.65	.0062
180 v 90 5FD	-1.90	1	33.93	10.96	.0011

Time

Contrast	Difference	DF	SS	F	PR>F
180 v 90 2FI	-18.12	1	3174.67	4.11	.0438
180 v 0 2FI	-34.65	1	12006.23	15.56	.0001
180 v 270 2FD	18.62	1	3230.85	4.19	.0420

Results for Card Set 2

Strokes

Contrast	Difference	DF	SS	F	PR>F
180 v 270 2FI	-2.3	1	48.00	9.07	.0029
180 v 0 2FD	2.1	1	37.81	7.14	.0081
180 v 90 5FI	-2.4	1	51.36	9.70	.0021
180 v 90 5FD	-1.6	1	22.42	4.23	.0408
180 v 270 5F	-2.2	1	48.11	9.09	.0029

Table 3 (continued)

Time

Contrast	Difference	DF	SS	F	PR>F
180 v 0 2FI	26.45	1	6514.27	7.64	.0062
180 v 90 2FD	31.03	1	8319.60	9.76	.0020
180 v 0 2FD	49.00	1	20726.28	24.31	.0001
180 v 270 2FD	25.32	1	5125.78	6.01	.0150

Results for Card Set 3
Strokes

Contrast	Difference	DF	SS	F	PR>F
180 v 0 2FI	-3.04	1	50.70	4.55	.0344
180 v 270 2FI	-2.43	1	65.88	5.90	.0162
180 v 90 2FD	3.50	1	73.90	6.62	.0110

Time

Contrast	Difference	DF	SS	F	PR>F
180 v 0 2FI	-52.88	1	15347.03	15.21	.0001
180 v 270 2FI	-35.67	1	6476.84	6.42	.0124

less time to complete than the lower left rotation. For 2FD subjects the upper right, lower right, and upper left quadrants tasks took significantly less time to complete than the lower left (see Table 3).

Card Set 3

The hypothesis was not supported for Card Set 3. For this card set both groups of second graders took significantly more time to complete the upper right and upper left quadrant tasks than they did the lower left. Second grade field independent subjects also used significantly more strokes in all these quadrants, while there were no significant differences for 2FD subjects for strokes (See Table 3).

Hypothesis 2

H2 There will be a significant pattern rotation (Quadrant) effect found between subjects based on cognitive style and grade level (5FI, 5FD, 2FI, 2FD) as measured by partial time for task completion and total number of keystrokes used to complete one-half of a problem-solving task.

(A) Fifth-grade field independent (5FI) subjects will score lower on the dependent measures (partial time to task completion and total number of keystrokes used) when problem-solving in all quadrants for the three card sets than will the other groups of subjects (5FD, 2FI, and 2FD).

Special contrasts for repeated measures ANOVA comparing each of the four groups of subjects on each rotation supported the hypothesis. When 5FI subjects were compared to 2FI subjects, the 5FI subjects used significantly fewer strokes to complete the lower left rotation in Card Set 1 and the upper left rotation in Card Sets 1,2, and 3. Also, 5FI used significantly less time to solve problems in all the quadrants for Card Set 1, the lower left and upper left quadrants for Card Set 2, and the lower right and upper left quadrants for Card Set 3 (see Table 4).

Fifth grade field independent (5FI) subjects differed significantly from 2FD subjects by using fewer strokes to complete all quadrant tasks for Card Set 1, the lower left and upper left quadrants for Card Set 2, and the upper left for Card Set 3. When these two groups were compared on Time they differed significantly on all quadrant tasks for Card Sets 1, 2, and 3 (see Table 4).

Finally, 5FI subjects differed significantly from 5FD subjects for strokes for the lower left rotation for Card Set 1, and the upper left rotation for Card Set 2. There were no significant differences between these subjects on either strokes or times for Card Set 3, and for times for Card Set 2 and 3 (See Table 4).

Table 4

The Results of Special Contrasts for Repeated Measures ANOVA for Comparisons Being Made Between Subjects Completing Problem-Solving Quadrant Tasks for Card Sets 1, 2, and 3

Results for Card Set 1

Strokes

Contrast	Difference	DF	SS	F	PR>F
180 2FI v 5FI	1.6	1	23.61	7.62	.0063
270 2FI v 5FI	1.2	1	12.75	4.12	.0437
90 2FI v 2FD	-2.8	1	73.75	23.82	.0001
180 2FI v 2FD	-2.7	1	70.03	22.62	.0001
90 2FD v 5FD	2.7	1	67.07	21.66	.0001
180 2FD v 5FD	3.1	1	91.95	29.70	.0001
0 2FD v 5FI	1.1	1	12.65	4.09	.0445
90 2FD v 5FI	3.2	1	99.34	32.08	.0001
180 2FD v 5FI	4.4	1	185.49	59.90	.0001
270 2FD v 5FI	1.4	1	11.95	3.86	.0508
180 5FI v 5FD	-1.2	1	13.93	4.50	.0351

Time

Contrast	Difference	DF	SS	F	PR>F
0 2FI v 5FD	46.0	1	19116.70	24.77	.0001
90 2FI v 5FD	50.6	1	24965.26	32.35	.0001
180 2FI v 5FD	46.7	1	19077.00	24.72	.0001
270 2FI v 5FD	45.5	1	18740.45	24.28	.0001
0 2FI v 5FI	49.6	1	23950.45	31.03	.0001
90 2FI v 5FI	47.8	1	22240.48	28.82	.0001
180 2FI v 5FI	46.5	1	19600.82	25.40	.0001
270 2FI v 5FI	46.9	1	19884.54	25.77	.0001
90 2FI v 2FD	-35.4	1	12091.28	15.67	.0001
180 2FI v 2FD	-28.8	1	7694.83	9.97	.0001
0 2FD v 5FD	46.9	1	19829.05	25.69	.0001
90 2FD v 5FD	86.0	1	69673.05	90.28	.0001
180 2FD v 5FD	75.5	1	53534.77	69.37	.0001
270 2FD v 5FD	61.4	1	34255.95	44.39	.0001
0 2FD v 5FI	50.4	1	24778.72	32.11	.0001
90 2FD v 5FI	83.2	1	65144.32	84.41	.0001
180 2FD v 5FI	75.3	1	55308.83	71.67	.0001
270 2FD v 5FI	62.8	1	34799.95	46.39	.0001

Table 4 (continued)

Results for Card Set 2
Strokes

Contrast	Difference	DF	SS	F	PR>F
270 2FI v 5FI	1.9	1	36.55	6.90	.0092
90 2FI v 2FD	-2.2	1	46.80	8.84	.0033
180 2FI v 2FD	-3.4	1	98.85	18.67	.0001
90 2FD v 5FD	1.8	1	29.46	5.56	.0192
180 2FD v 5FD	3.6	1	111.44	21.05	.0001
180 2FD v 5FI	3.7	1	113.13	21.37	.0001
270 2FD v 5FI	2.3	1	48.32	9.13	.0028
270 5FI v 5FD	-1.7	1	28.90	5.46	.0204

Time

Contrast	Difference	DF	SS	F	PR>F
90 2FI v 5FD	27.7	1	7395.92	8.67	.0036
180 2FI v 5FD	40.1	1	15543.62	18.23	.0001
270 2FI v 5FD	42.6	1	17495.99	20.52	.0001
180 2FI v 5FI	29.5	1	8008.89	9.39	.0025
270 2FI v 5FI	52.0	1	26078.80	30.59	.0001
0 2FI v 2FD	-25.7	1	5950.63	6.98	.0089
90 2FI v 2FD	-30.4	1	8919.84	10.46	.0014
180 2FI v 2FD	-48.2	1	20788.99	24.38	.0001
0 2FD v 5FD	38.3	1	13157.85	15.43	.0001
90 2FD v 5FD	58.1	1	31426.01	36.86	.0001
180 2FD v 5FD	88.3	1	67641.74	79.33	.0001
270 2FD v 5FD	51.6	1	23766.63	27.87	.0001
0 2FD v 5FI	40.0	1	15448.94	18.12	.0001
90 2FD v 5FI	46.0	1	18852.49	22.11	.0001
180 2FD v 5FI	77.7	1	50206.70	58.88	.0001
270 2FD v 5FI	61.0	1	33223.78	38.97	.0001

Table 4 (continued)

Results for Card Set 3
Strokes

Contrast	Difference	DF	SS	F	PR>F
270 2FI v 5FD	3.2	1	55.50	4.97	.0271
270 2FI v 5FI	3.1	1	52.90	4.74	.0309
270 2FD v 5FD	3.3	1	94.10	8.43	.0042
270 2FD v 5FI	3.3	1	89.89	8.05	.0051

Time

Contrast	Difference	DF	SS	F	PR>F
0 2FI v 5FD	98.6	1	63574.60	63.0	.0001
90 2FI v 5FD	57.8	1	22442.21	22.24	.0001
180 2FI v 5FD	30.2	1	6800.56	6.74	.0103
270 2FI v 5FD	72.8	1	29237.92	28.97	.0001
0 2FI v 5FI	84.6	1	46746.87	46.33	.0001
90 2FI v 5FI	50.0	1	16705.14	16.55	.0001
180 2FI v 5FI	39.8	1	11435.97	11.33	.0009
270 2FI v 5FI	68.2	1	25628.31	25.40	.0001
180 2FI v 2FD	-28.01	1	4962.49	4.92	.0279
0 2FD v 5FD	82.0	1	46629.82	46.21	.0001
90 2FD v 5FD	57.3	1	22204.57	22.00	.0001
180 2FD v 5FD	58.2	1	26105.85	25.87	.0001
270 2FD v 5FD	72.8	1	44924.91	44.52	.0001
0 2FD v 5FI	68.0	1	32023.28	31.74	.0001
90 2FD v 5FI	49.5	1	16491.49	16.34	.0001
180 2FD v 5FI	67.8	1	34259.55	33.95	.0001
270 2FD v 5FI	68.1	1	39369.84	39.02	.0001

(B) Fifth-grade field dependent (5FD) subjects will have significantly lower scores on all dependent measures (partial time to task completion and total number of keystrokes used) for Card Sets 1, 2 and 3 as compared to 2FI or 2FD subjects.

Special contrasts for repeated measures ANOVA partially supported this hypothesis. Fifth grade field dependent (5FD) subjects used significantly fewer strokes than 2FD subjects to complete tasks in the lower right and lower left quadrants for Card Sets 1, 2 and 3. Also, 5FD subjects differed significantly
from 2FD subjects for all quadrant tasks concerning times for Card Sets 1, 2 and 3 (see Table 4).

When 5FD subjects were compared to 2FI subjects significant differences were revealed for times. The 5FD took significantly less time to complete all quadrant tasks for Card Set 1, and the lower right, lower left, and upper left quadrant tasks for Card Set
2. There were no significant differences revealed for strokes (See Table 4).

(C) Second-grade field independent (2FI) subjects will score significantly lower on all dependent measures (partial time to task completion, total number of keystrokes used) for Card Sets 1, 2, and 3 than will second-grade field dependent (2FD) subjects.

Special contrasts for repeated measures ANOVA comparing 2FI and 2FD subjects on all measures for Card Sets 1, 2 and 3 partially supported this hypothesis. Second grade field independent (2FI) subjects used significantly fewer strokes and took signficantly less time to complete the lower right and lower left quadrant tasks for Card Sets 1 and 2 and the lower left quadrant for Card Set 3 than did 2FD subjects. Also, these groups differed on the upper left quadrant for times, with 2FI subjects taking less time to complete problem-solving tasks than 2FD for Card Set 2 (See Table 4).

<u>Hypothesis 3</u>

The measures of Comprehension Monitoring used were the following:

(1) CMTOT--the total score on the Comprehension Score Sheet (CMSS) (Appendix 2). CM1-CM4 are the first four question on the CMSS.

(2) CM1--The child generated hypotheses for task completion.

(3) CM2--The child planned ahead.

(4) CM3--The child compared alternatives.

(5) CM4--The child evaluated outcomes.

As mentioned at the beginning of this chapter the data were calculated for only one set of analyses, because the experimenter scored each child the same for each card set on the CMSS.

H3 There will be a significant interaction between cognitive style and grade level for subjects as measured by discrete measures of Comprehension Monitoring (CMTOT, CM1, CM2, CM3, and CM4).

(A) Fifth-grade field independent subjects will score significantly higher on all dimensions of comprehension monitoring (CMTOT, CM1, CM2, CM3, and CM4) for all Card Sets.

Tukey's (HSD) comparisons (alpha set at .05) were calculated to determine which means of the discrete measures of comprehension monitoring were significantly different when comparing and/or contrasting the four groups of subjects. The analyses provided support for the hypothesis. 5FI subjects scored significantly higher on all measures of comprehension monitoring when compared or contrasted with both groups of second graders. 5FI also scored significantly higher on CM 1 (generating hypothesis) and on CM 3 (comparing alternatives) than 5FD subjects. There were no significant differences found between 2FDs and 2FIs (See Table 5).

(B) Fifth-grade field dependent subjects will score significantly higher on all measures of comprehension monitoring (CMTOT, CM1, CM2, CM3, CM4) for Card Set 1 and Card Set 2 when compared with second grade field independent subjects and second grade field dependent subjects.

Here again the Tukey's (HSD) comparisons (alpha set at .05) provided support for this hypothesis. 5FD subjects scored significantly higher than 2FD subjects on CM2 (planning ahead) and CM 3 (comparing alternatives). When 5FD subjects were compared with 2FI subjects significant differences were revealed for CM 2 (planning ahead) and CM 4 (evaluating outcomes). No other significant differences were observed (See Table 5).

(C) Field independent second graders will score significantly higher on all measures of comprehension monitoring (CMTOT, CM1, CM2, CM3 and CM4) than will field dependent second graders.

Tukey's (HSD) comparisons (alpha set at .05) revealed no significant differences found between these groups, therefore, the hypothesis was not supported (See Table 5).

Table 5

Results of Tukey's (HSD) Comparisons for

Measures of Comprehension Monitoring (alpha = .05)

CM Measure	Comparison	Difference
CM 1	2FI v 5FI	-.4132
	2FD v 5FI	-.4500
	5FD v 5FI	-.5000
CM2	2FI v 5FI	-.5237
	2FI v 5FD	-.3737
	2FD v 5FI	-.6000
	2FD v 5FD	-.4500
CM3	2FI v 5FI	-.5842
	2FD v 5FI	-.8500
	2FD v 5FD	-.5000
	5FD v 5FI	-.3500
CM4	2FI v 5FI	-.6289
	2FI v 5FD	-.3789
	2FD v 5FI	-.3500

The Results for CM Total were repoted as follows:

		Mean	Group
	A	50.95	5FI
	A		
B	A	48.25	5FD
B			
B		46.20	2FD
B			
B		45.70	2FI

Means with the same letters are not significantly different.

CHAPTER V

DISCUSSION

General Findings

This study was designed to empirically investigate how young children learned to use LOGO broken down by grade level (second versus fifth) and cognitive style (field independence (FI) versus field dependence (FD)) and their effects on spatial development. Dunn, et al. (1977) and Saracho (1984) stated that cognitive style is one of the most significant factors contributing to a child's success at school. Field independent learners (FI) are internally motivated and generally utilize the existing cues from the environment. Field dependent learners (FD) need external reinforcement and frequently ignore cues from the environment.

From a Piagetian perspective (Mussen, 1984; Rohwer, 1974), second graders are operating within a transitional stage between preoperations and concrete operations. These children are generally less egocentric than preoperational children, and are beginning to engage in representational thought. Operating from within the concrete operations stage, fifth graders have developmentally coordinated mental structures and are able to approach problems with more logic than preoperational children. Because of the ability to engage in reversability, fifth graders can respond to problems that require focusing on more than one aspect at a time.

Piaget and Inhelder (1967) and Lowery & Knirk (1982-1983) wrote that spatial development can be broken down into three stages: the Topological stage, the Projective stage, and the Euclidean stage. During the Topological stage children learn to operate spatially from an egocentric perspective. From this stage children move into the Projective stage where they are able to view objects from an imaginary "other" point of view. Finally, children come to understand the relationships of angles and distance during the Euclidean stage.

Based on the literature cited above, this researcher hypothesized that fifth grade field independent children would be more successful at completing spatial problem-solving tasks using LOGO programming than would fifth grade field dependent or second grade field independent/field dependent children. Papert (1980), however, hypothesized that one of the features of LOGO is that it allows a child to operate within an Euclidean frame of reference even if they have not reached that stage of development. This study, therefore, was also investigating whether second graders would do as well on LOGO problem-solving tasks regardless of their stage of spatial development.

Before discussing the results of the hypotheses tested, several non-hypothesized findings of interest will be presented. The first finding is that all children involved in this study learned to program in LOGO. As mentioned in the Introduction to Chapter 1, the results of studies concerned with children learning to program in LOGO are inconclusive. Some researchers (Kurland & Pea, 1984; Hawkins, et al., 1982) reported that preoperational children were unable to master the complexities of fundemental LOGO programming. By "complexities" the above researchers generally meant the mastery of LOGO syntax and semantics (the language and logic of LOGO programming).

However, as mentioned above, Papert (1980) stated that children, after learning some basic programming commands, can operate within the LOGO environment regardless of their level of cognitive or spatial development. This is because LOGO provides them with a powerful vehicle with which to think. This "vehicle" is the "microworld" created within the computer's screen. By communicating with the "turtle" the child learns to "think about their own thinking": therefore, developing a "mind set" which allows them to benefit from LOGO programming without having mastered LOGO syntax and semantics.

Studies which support the Papert position are Watson and Busch, (1989), Brinkley, (1989), Fay and Mayer, (1987), Campbell, et al., (1986), Clements and Gullo, (1984). These authors demonstrated that preschool and younger elementary children can learn enough LOGO programming skills to move around the computer's screen, thereby solving age-appropriate problems. In research studies by Brinkley (1989), Brinkley and Watson (1989), and Rembert and Watson (1989) fundamental LOGO problem-solving skils (moving Forward, Backward, Right, and Left) were successfully taught to young children within a three week period working approximately 20 minutes a day.

As a second finding, we successfully taught these fundamental skills to the young subjects within five daily sessions of 20 minutes apiece. It should be noted that the subjects in this study had had previous experiences with computers-all students in the North Carolina public schools must receive computer instruction weekly. Even though they had had these experiences none of the subjects were familiar with LOGO programming prior to being instructed during this study.

In summary, the subjects in this study were (1) able to learn fundamental LOGO programming skills within five 20 minute sessions, and (2) were able to solve twelve spatial problem-solving tasks. These findings contribute to the growing body of literature supporting Papert's contention and the position of the Children and Technology Project at the University of North Carolina at Greensboro, which is that programming with LOGO creates a "mind set" allowing children to function, at least at a minimum level, within the LOGO microworld.

Hypothesis 1

The results from Hypothesis 1 indicated that for Card Set 1 and Card Set 2 second grade field dependent (2FD) subjects evidenced more difficulty problem-solving in the lower quadrants, when considering keystrokes, than they did in the upper quadrants. These results support Brinkley's (1989)
finding that the subjects in her study were more successful in problem-solving in the upper quadrants than they were in the lower ones. She concluded that these children were utilizing egocentric spatial abilities (syntonic learning strategies) in the upper quadrants, but that these strategies were "invalidated" in the lower ones. In contrast to the 2FD, second grade field independent (2FI) did not evidence the difficulty 2FD had when problem-solving in these quadrants.

Fay and Mayer (1987) have stated that the most important factor to consider when problem-solving in LOGO is the heading of the turtle (the direction in which it is pointing). This relates to the results discussed above, but it also relates to Campbell, et al.'s, (1986) theory that after children rely on an egocentric (grid system) strategy, they move into concentric circle strategy where the turtle becomes the center of a series of concentric circles. This, therefore, allows the child more flexibility of movement. While 2FI have not relinquished totally their use of egocentric strategies, they appear to be using beginning concentric circles stategies while problem-solving. These two stategies coupled together permit 2FI's increased flexibility of movement and account for differences evidenced between the two groups. These data provide support for the Watson & Busch (1989) model explaining the developmental sequence children use in LOGO.

A finding that was not necessarily expected was that fifth grade field dependent (5FD) subjects performed in a similar manner to the 2FI on problem-solving tasks for Card Set 1. This was not expected because fifth graders would be expected to perform in a more advanced manner from second graders. An explanation for these results can be found in the cognitive style literature. Dunn, et al., (1977), Saracho, (1984), and Kogan (1973) write that one of the characteristics associated with being field independent (FI) is that FI individuals are able to separate the existing field into its component parts. FI individuals also are able to use the existing cues from their environments. Field dependent (FD) individuals do not separate the existing field into its component parts, but view it as a whole. They are also limited in using the existing cues from the environment. Drawing upon the Watson and Busch (1989), Fay and Mayer (1987) and Campbell, et al., (1986) literature, being able to perceive that the turtle's heading and the fact that after it has moved it has become the new center for a series of concentric circles may be a task that is more difficult for FD individuals than it is for FI. In order to perceive this new heading, individuals have to be able to recognize the cues inherent within the problem-solving task and the computer's screen, as well as being able to separate the turtle's present position from the problem-solving task being replicated. These facts would indicate that while 5FD are generally more advanced cognitively and spatially, they also can experience difficulties in problem-solving due to the characteristics of their cognitive styles. 2FI, on the other hand, have the advantage of being able to benefit from existing cues, and are able to separate the turtle's present position from the problem-solving task. When coupled together, the above factors explain how 2FI and 5FD subjects could problem-solve in a similar manner when replicating spatial tasks.

The above factors help to explain how only FD subjects differed when problem-solving for Card Set 2. This card set was considered to be mid-level in difficulty, requiring both 45 and 90 degree turns. Again, FI subjects would be expected to have the advantage, while these problem-solving tasks would present difficulties for FD. This appears to have been the case. As with Card Set 1, the lower left quadrant took less time to problem-solve than the upper right. This is explained by the subject realizing that when problem-solving in the lower left quadrant, the turtle's heading is brought more in line with the subject's body. When this is coupled with the fact that the turtle can be viewed as being the center of a new series of concentric circles, subjects being able to perceive this would have less difficulty than those who can not.

An alternative explanation for second graders that should be mentioned relates to Piaget's supposition that second graders are generally considered to be operating from within a transitional period as they move from the preoperational to the concrete operational stages of development. Brinkley's (1989) study was conducted with 4-and 5-year-old children. These younger children are considered to be operating from a preoperational perspective, and performed in a manner similar to the 2FD subjects in this study. An explanation for this phenomenon might be that, while second graders are in a transitional stage, this transition benefits 2FI more than it does 2FD.

For Card Set 3 all subjects had more difficulty problem-solving in the lower right quadrant than they did in the upper right. This is the first task with which fifth grade field independent subjects (5FI) have had difficulty. This would indicate that, while 5FI subjects have generally demonstrated advanced problem-solving stategies to this point, there are limits to their abilities.

In summary, Hypothesis 1 demonstrated that the subject's abilitiy to employ egocentric (syntonic) learning strategies and the subject's ability to perceive the heading of the turtle and its location as the center of a series of concentric circles contribute to the subject's problem-solving abilities within the four quadrants. Hypothesis 1 also demonstrated that these factors were found to be responsive to the subjects' cognitive style, more so than their grade levels. For this study FI subjects were better able to problem-solve than FD, with 5FI having advanced skills when compared to the other groups, especially second graders. Hypothesis 1 also revealed that 2FI and 5FD subjects performed in a similar manner for Card Set 1.

Hypothesis 2

Hypothesis 2 specifically compared the four groups of subjects (5FI, 5FD, 2FI, and 2FD) with each other (Hypothesis 1 compared each group with themselves). In general second graders differed from fifth graders on times for all problem-solving tasks for Card Sets 1, 2, and 3. The only exception to this was 2FI subjects when compared to 5FI for Card Set 2 for the upper right and lower right quadrants. Next, 2FI differed from 2FD for the lower left quadrants for Card Sets 1, 2, and 3, and the lower right quadrants for Card Sets 1 and 2. Finally, fifth graders did not differ from each other.

The differences for times were also found for strokes. The results of Hypothesis 2 indicate that 2FD are better able to problem-solve in the upper quadrants than they are in the lower quadrants (this was also revealed in Hypothesis 1). Second grade field independent and 5FD evidenced no problems with problem-solving for any quadrant for Card Sets 1 and 2. The reasons for these findings would follow the logic presented in Hypothesis 1.

In reviewing the results of Hypothesis 2, it becomes apparent that none of the groups differed in their performance in the upper right quadrant. This finding lends support to Hypothesis 1 (A) that the upper right quadrant is less difficult with which to problem-solve than the other three and that there is a quadrant effect when utilizing LOGO. Also, the data revealed that FD subjects differed in their problem-solving abilities between the upper and lower quadrants, with the upper quadrants being less difficult. This finding supports the hypothesis that a quadrant effect exists for the subjects involved in this study. Finally, the data, when comparing FI subjects with 5FD, indicates a third pattern. This pattern reveals that for these subjects the lower left quadrant (for Card Set 1) and the upper left quadrants (for Card Sets 1, 2, and 3 for 2FI; Card Set 2 for 5FD) are spatially different. These differences are not as strong for 5FD, however, because fifth graders did not generally differ from each other. It should be noted that when 2FI is compared to 5FD the differences are limited, but when these two groups are compared to 5FI, a pattern is evidenced.

This pattern involves the upper left quadrant. As discussed earlier, problem-solving in the upper quadrants is related to being able to adequatly employ egocentric learning strategies. FI are better able to utilize existing cues from within the environment in order to determine the movements necessary for problem-solving. When considering these factors together, the differences found can be explained by considering that these strategies can come into conflict when problem-solving in the upper quadrants. This would happen when the subject tries to apply both an egocentric strategy and a turtle centered strategy at the same time. 5FI evidenced less difficulty when problem-solving in these quadrants. Because of the grade level and cognitive style differences mentioned, these problem-solving conflicts seem to have been resolved.

<u>Hypothesis 3</u>

To date little research has been conducted into how comprehension monitoring relates to the accomplishment of a specific task. The research that has been conducted has either concentrated on determining whether comprehension monitoring skills can be taught to various age groups, or how interacting within the LOGO microworld environment aids the development of comprehension monitoring skills. This study involved instructing the subjects in the comprehension monitoring model developed by Miller (1985) and then evaluating how the comprehension monitoring skills learned contributed to the subject's problem-solving abilities.

The results of this analysis indicated that 5FI had significantly higher scores on all measures of comprehension monitoring than both groups of second graders. 5FD had significantly higher scores on comprehension monitoring when compared to both groups of second graders for planning ahead (CM2). 5FD also differed significantly from 2FD on comparing alternatives (CM3) and from 2FI on evaluating outcomes (CM4). Second graders did not differ from each other, while fifth graders differed significantly from each other on generating hypothesis (CM1) and comparing alternatives (CM3).

The above results indicate that 5FD and both groups of second graders did not differ in their abilities to generate hypotheses, but they did differ in their abilities to plan ahead. Fifth grade field dependents also differed from 2FI in their abilities to evaluate outcomes and 2FD in their ability to compare alternatives. These differences can be explained partially by levels of cognitive development, but they can also be explained by the characteristics inherent in cognitive style. As mentioned previously, FD is characterized as being externally motivated, being people oriented, and FI as being internally motivated, not people oriented. Also FD are characterized by not being able to separate the whole from its parts, while FI have the ability to do this. These two characteristics used for 2FD explain how they lack the ability to compare alternatives (see the many parts that may make up the whole) and for 2FI the difficulty with which they have evaluating outcomes (not interacting with others to determine what may have happened, and not having the degree of cognitive development necessary to do it themselves). Second grade field dependents, on the other hand, are more social and may interact with others in order to help them determine what they have done and how they might improve later.

When 5FI was compared to 5FD, 5FI scored significantly higher in generating hypotheses (CM1) and in comparing alternatives (CM3). These results also indicate that like 2FD, 5FD lack the abilities to separate the whole from its parts (generating hypotheses and comparing the alternatives available to them).

The Watson and Busch Model

The findings from this study have provided support for the Watson and Busch (1989) model of spatial thinking (levels I, III, IV and V). Watson & Busch propose a six level model that incorporates the perspectives suggested by Campbell, et al. (1986). The general findings indicated that the subjects learned enough LOGO syntax (LOGO commands) to be able to problem-solve and that this syntax was learned over five twenty-minute sessions. This finding supported the Level I of the model. This level suggests that children must learn a minimum number of commands in order to move about the screen. Level II thinking was tested and supported by Brinkley (1989) and suggests that once the syntax is learned that children initially turn or "point the turtle in the direction they want it to go and then move it."

Level III thinking involves the child using a "grid system" for movement on the screen. This does not mean that the child views the screen as a grid, but that the child uses basic movements that approximate grids. These movements are characterized by the use of 90 degree turns and problem-solving tasks being more accurately performed in the upper right quadrant. This finding was supported for all subjects in this study.

The grid system plus beginning concentric circle system characterizes Level IV thinking. The child, once mastering the grid system, is now turning his/her attention to moving the turtle at angles other than 90 degrees. These movements can be made without having developed formal mathematical concepts by turning the turtle in the directions the child wants to go and then moving it. Second grade field independents and fifth graders demonstrated that they could problem-solve in quadrants in which the positioning of the turtle was an important factor relating to movement. Second grade field dependent subjects did not demonstrate this ability.

Level V, Campbell et al.'s (1986) concentric circle perspective, was also supported in this study. It is during this level that children recognize that the turtle's movements (right, left, up, and down) can be performed from any position on the screen. The subject is able to take a "turtle-centric" viewpoint when problem-solving. It appears that 5FI subjects were operating within this level, by generally performing equally well within all quadrants for all card sets. Level VI thinking extends the concentric circle perspective from the two-dimensional limitations of the computer's screen into three-dimensional space. A child operating at Level VI would understand the "wrap-around" feature of the LOGO program, and could accurately predict the point the turtle would return to after leaving the screen.

Chapter VI

SUMMARY AND CONCLUSIONS

This study was undertaken to empirically test how cognitive style and grade level relates to spatial development and comprehension monitoring. Eighty subjects were randomly selected from the fifth (20 FD/20 FI) and second (20 FD/20 FI) grades. The subjects were instructed over a five day period in the fundamental commands necessary in order to manipulate the turtle within LOGO's microworld. Once these skills were learned, the subjects were instructed to complete a series of three Card Sets requiring them to replicate four problem-solving tasks. These tasks consisted of 90 degree turns only, 45 and 90 degree turns, and 45 degree turns only. These tasks ranged from least difficult (90 degree turns only) to the most difficult (45 degree turns only). Results for comprehension monitoring testing was determined from the subjects' scores on the Comprehension Monitoring Score Sheet.

Hypothesis 1 showed that the subject's ability to employ egocentric (syntonic) learning strategies and their ability to perceive the heading of the turtle and its location as the center of a series of concentric circles contributed to the subject's problem-solving abilities within the four quadrants. Also, Hypothesis 1 demonstrated that these factors were found to be responsive to the subject's cognitive style, more so than their grade levels. For this study FI subjects were better able to problem-solve than FD, with 5FI having advanced skills when compared to the other groups, especially second graders. Hypothesis 1 also revealed that 2FI and 5FD subjects performed in a similar manner for Card Set 1.

Hypothesis 2 specifically compared the four groups of subjects (5FI, 5FD, 2FI, and 2FD) with each other. Hypothesis 1 compared each group with themselves. In general, second graders differed from fifth graders on all problem-solving tasks for Card Sets 1, 2, and 3. The only exception to this was 2FI subjects when compared to 5FI for Card Set 2 for the upper right and lower right quadrants. Next, 2FI differed from 2FD for the lower left quadrants for Card Sets 1, 2, and 3, and the lower right quadrants for Card Sets 1 and 2. Finally, fifth graders did not differ from each other.

Three major findings were related to quadrant differences. The first was that the upper right quadrant was less difficult with which to problem-solve for all subjects than were the other three, when all groups were compared together. Next, the study revealed that FD subjects differed in their problem-solving abilities between the upper (upper right and upper left) and lower quadrants (lower right and lower left). Finally, a third pattern of quadrant problem-solving was shown for FI and 5FD subjects, which was that the lower left quadrant for Card Set 1 and the upper left quadrants for Card Sets 1, 2, and 3 were spatially different (more difficult) for 2FI. The lower left quadrant of Card Set 2 was also more difficult for 5FD. This spatial difficulty may be attributed to the interaction of egocentric problem-solving strategies and the ability of FI to better realize that further movements of the turtle are dependent upon the positioning of the turtle coming into conflict with each other and leading to increased difficulty.

The results of the analysis for Hypothesis 3 indicated that 5FI had significantly higher scores on all measures of comprehension monitoring than both groups of second graders. Fifth grade field dependents had significantly higher scores on comprehension monitoring when compared to both groups of second graders for planning ahead (CM2). Also, 5FD differed significantly from 2FD on comparing alternatives (CM3) and from 2FI on evaluating outcomes (CM4). Second graders did not differ from second graders, while fifth graders differed significantly from each other (FI had better scores) on generating hypothesis (CM1) and comparing alternatives (CM3).

It can be concluded from this study that cognitive style and grade level, when evaluated together, provide information about spatial development and comprehension monitoring that would not have been possible if the analysis had been conducted with each varaiable separately. This analysis further provided support for Campbell, et al. (1986) and the Watson & Busch (1989) model which state that subjects first use an egocentric perspective in order to problem-solve and next develop an abilitiy to view the positioning of the turtle as the point from which further movements need to be made. This newly developed ability provides the child with increased fexibility of movement and leads to less difficulty with spatial problem-solving. The study also indicated that the subject's ability to problem-solve was related to the quadrant in which he/she was working which supports the Watson & Busch model (1989). Related to this observation was the finding that subjects in different grade levels and having different cognitive styles experienced difficulty problem-solving in different quadrants. Finally, measures of comprehension monitoring differed between groups based upon cognitive style and grade level with 5FI having the most advanced degree of comprehension monitoring skills and 2FD having the least.

Recommendations for Future Research

1. Further research is needed to explain cognitive styles and spatial development of children who are going through a transitional stage of development. Specifically, research should be designed to determine the role cognitive style plays during the transitional period.

2. Further research is needed to clarify the spatial problem-solving abilities of subjects in higher grade levels in the formal operations stage. The suggested research might be used to determine whether cognitive style plays more or less of a role during problem-solving as the child matures. A second direction for future research would be to determine whether cognitive style is less differentiated in children below the second grade, and if it is, are there predictors of their future orientation?

3. Further research is needed in order to understand how children learn comprehension monitoring skills and how they apply these skills once learned.

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Appendix 1

Letter to Parents

Dear Caretaker:

Your child ______________________ has been selected at random to participate in a computer study being conducted at Altamahaw-Ossipee Elementary School.

This study is designed to evaluate kindergarten, second, and fifth grade student's spatial development. The children selected will be trained to use several LOGO computer commands and then asked to replicate some patterns using the commands. LOGO is a programming language that has been developed for children to use. These children will also be taught a comprehension technique throughout their training sessions. This technique is designed to help them think about a task before they begin to do it. Finally, the children will be administered a short test in order to determine their preferred way of accomplishing a task.

This study will be conducted over a 5 week period and will involve your child being out of the classroom a total of nine 20-minute sessions over a two week period. All testing and instruction will be conducted during these sessions. The exception to this will be kindergarten children who will be involved in a three week training period after which a one week testing period will begin. In no way will the results from this study affect your child's grades in school.

Please indicate below whether your child may participate in this study. If you indicate that your child may participate and later reconsider, or if your child wants to stop participating, he/she may stop.

Thank you for your consideration.

Charles E. Easton, Doctoral Candidate
Department of Child Development and Family Relations
University of North Carolina at Greensboro

____ My child has permission to participate in this study.

____ My child may not participate in this study.

Caretaker's signature ______________________________

___ I would like to receive a summary of the results of this study. Please send the summary to me at the address given below:

____

____

____

(Name, city, state, zip code)

Appendix 2

Comprehension Monitoring Score Sheet

Child's Name: ________________________ Date: ____________

Answer the following questions using the 5 point scale below.

Strongly disagree	Disagree	Undecided	Agree	Strongly Agree
1	2	3	4	5

1. The child generated hypotheses for task completion.	1	2	3	4	5
2. The child planned ahead.	1	2	3	4	5
3. The child compared alternatives.	1	2	3	4	5
4. The child evaluated outcomes.	1	2	3	4	5
5. The child and I verbalized at a high rate.	1	2	3	4	5
6. There were mostly teacher initiated comments.	1	2	3	4	5
7. There were mostly child initiated comments.	1	2	3	4	5
8. The teacher provided the majority of the directions.	1	2	3	4	5
9. The child provided the majority of the directions.	1	2	3	4	5
10. The teacher initiated most of the interactions.	1	2	3	4	5
11. The child initiated most of the interactions.	1	2	3	4	5
12. The child's ability to think out loud was good.	1	2	3	4	5
13. The child knows a lot about his/her thinking concerning the task (s).	1	2	3	4	5
14. The child's motivation was high.	1	2	3	4	5
15. The child understands how to monitor his/her comprehension.	1	2	3	4	5
16. The child's ability to monitor his/her thinking was good.	1	2	3	4	5

Total score for comprehension Monitoring (add the circled numbers for questions 1-16). __________

Appendix 3

Problem-Solving Score Sheet

											Train	0°	90°	180°	270°
Figure	I.	0°	90°	180°	270°	II	0°	90°	180°	270°	III.	0°	90°	180°	270°

Distance															
Direction															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

Distance															
Direction															
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

Individual ________

Rater ________

Time For Task Completion	1/2	3/4	Fully

Appendix 4

Comprehension Monitoring Questions

1. Designed to help the child generate hypotheses.

A. What did you have to do in this lesson?

B. What do you have to do in order to complete this task?

C. What did you tell the computer/turtle to do?

D. If I wanted to do what you did, what would I have to do?

2. Designed to help the child plan ahead.

A. What do you want the computer/turtle to do?

B. What do you have to do first? Next?

C. What do you have to tell the computer/turtle to do?

3. Designed to help the child compare alternatives.

A. What could you tell the computer/turtle in order to do this task in another way?

B. Which way was the best way?

C. Is there only one way to do this?

4. Designed to help the child evaluate the outcome.

A. What did you just do?

B. Is the task complete? Have you finished the task?

C. What mistakes did you make?

D. What have you learned (during this session and from the mistakes)?

Appendix 5

Sample Session 1

Greet child/get child. Introduce child to computer and the LOGO turtle we call "TINA".

Generally talk about prior experience with computers and possible experiences with LOGO. Tell them that LOGO is a computer program that allows you to tell the computer (actually) the turtle "TINA" what to do. Ask if they would like to meet TINA and learn to tell her something to do. (The computer can already be on or you can now turn it on and "boot" the program up.) Type ST (Show Turtle) and press return and have the turtle appear.

Tell the child that now he/she is going to learn 3 commands. As the week goes on he/she will learn several more commands. But for today he/she will work on FD 10 (Forward 10); FD 20 (Forward 20); RT 90 (Right 90). First, lets learn where the characters are located the "F", "D", "R", "T", "1", "2", and ’0". The "F" is located here. The "D" is located here. Let’s press the "F"--good. Now the "D". You have to press the "F" first and the "D" next. Now press the space bar. It is right here (point to it). Let’s see what happens when you do that. If you go too far you can press the delete key and go back and correct the movements or the mistakes you may make. Let’s press delete and go back to the beginning.

OK now press the "F" and the "D" again and the space. Good (or have the child correct the mistake if needed). Now look at the top line. There are only numbers up there. You will use these keys to make the numbers that go with the letters. The "1" is here. Press the "1". The "0" is here. Press the "0". (When needed show where the "2" is and use in the same way. When you press FD and either 10 or 20 what does TINA do? Let's see. In order to get TINA to move you must press FD (space) 10 or 20 and the return key. You can do it now. What happened. (TINA moves). Now press the next command (either FD 10 or FD 20).

Let's do some more and this time you tell me what you have to do (tell TINA to go forward either 10 or 20 steps). Tell the child that was very good or correct their thinking if it is incorrect (You want to tell TINA to move forward 10 or 20 steps).

Ok lets see if you can make TINA move. Allow the child time to do this. If they cannot show them what to do and then give them time to try it again. Encourage them to use all the key instructed on.

If they make a mistake first ask them to try to figure out what they did wrong. Encourage them to correct their own mistakes, but if they cannot figure it out show them what they did wrong.

Once the move has been made ask the child to decide if they have made a correct move (if it looks ok to them). If it does , tell them to give themselves a "pat-on-the-back". or tell themselves they "are doing well."

After doing several forward moves, both 10 and 20, introduce the RT 90 command. Tell them that this command to turn to the right 90 degrees. Show the child where the keys are much like you did above. Practice using it. Go through the questions above while using the RT command as you did with the FD.

When the subject has practiced the commands a few times as them to tell you what they have learned to this point. Ask them if they had made any mistakes and if they have what they have learned from them.

(if time permits) Ask the child if they would like to learn to make a square. Show them a picture of one and tell then the task is to make a square. Next, ask them what they think they will need to do (using the 3 commands they have learned to make the square. Once they have given you an answer tell then to try it. (give encouragement if need and praise where appropriate.) If the subject is stuck, go through the process aloud for them. Once you have done this, ask them to go through the process aloud themselves.

As the child goes along ask them to evaluate how well they are doing. If appropriate to give themselves a "pat-on-the-back". IF they are making mistakes correct them.

Once they have completed they square ask them what they have learned.

At the end of the session (a session lasts 15 minutes) tell the child they did a good (great) (terrific) (super) job and that you will see them tomorrow and the two of you will learn some more commands.

Take back to class.

Get another child---Begin again.

Sessions 2-4 will be much the same.

Session 5 will be the training test---During this session you will review all commands with the child and then ask them to use the commands they have learned to replicate four patterns contained on the cards. As the child works on these cards the adult will be recording the movements made as well as the time it takes them to complete the figure.

As the session goes on the adult will also ask the child several questions from the Comprehension Monitoring question sheet and record the answer if possible. Once the child has completed the card (or if the 3.5 minute time limit has been reached) the next card is begun.

Session 6-8 is the actual problem-solving test sessions. The adult will present the cards to the child (four for each session) (Session 6--Problem-solving set 1) (Session 7--Problem-solving set 2) (Session 8--Problem-solving set

3). All times and keystrokes are recorded. The child is also asked comprehension monitoring questions.

Appendix 6

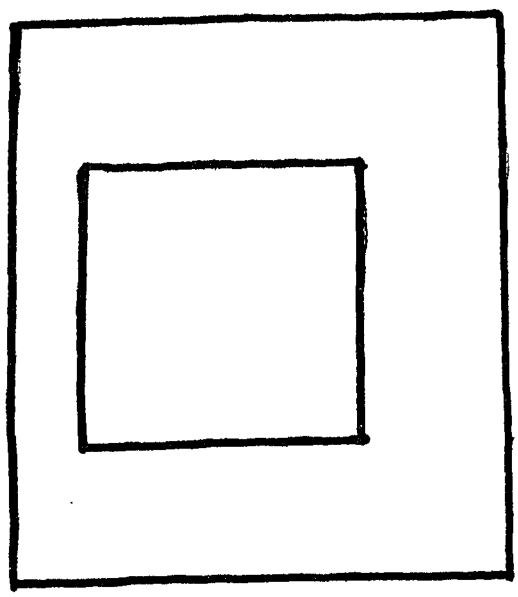


Figure 1

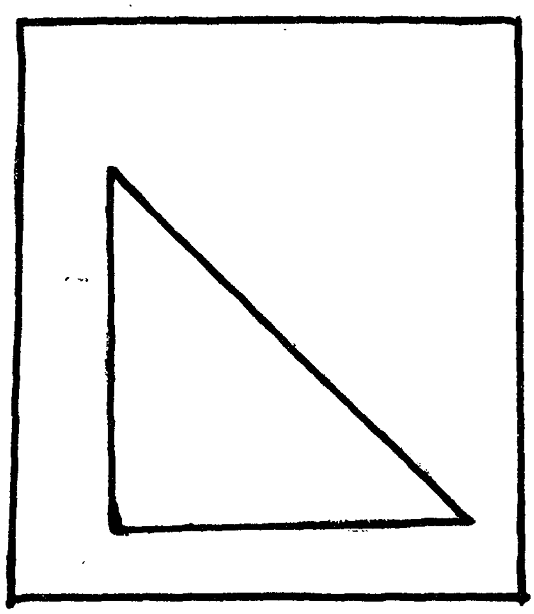


Figure 2

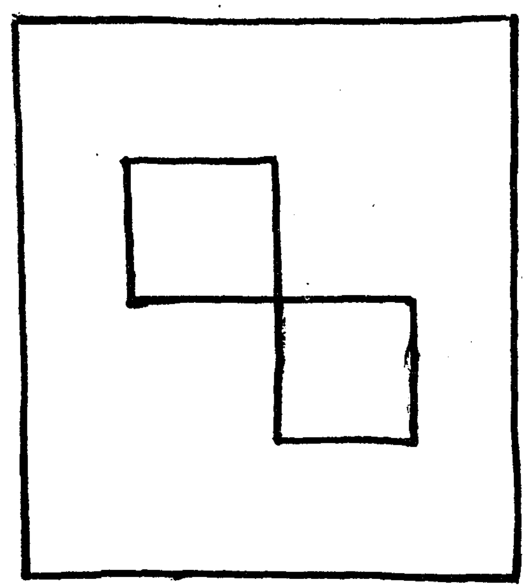
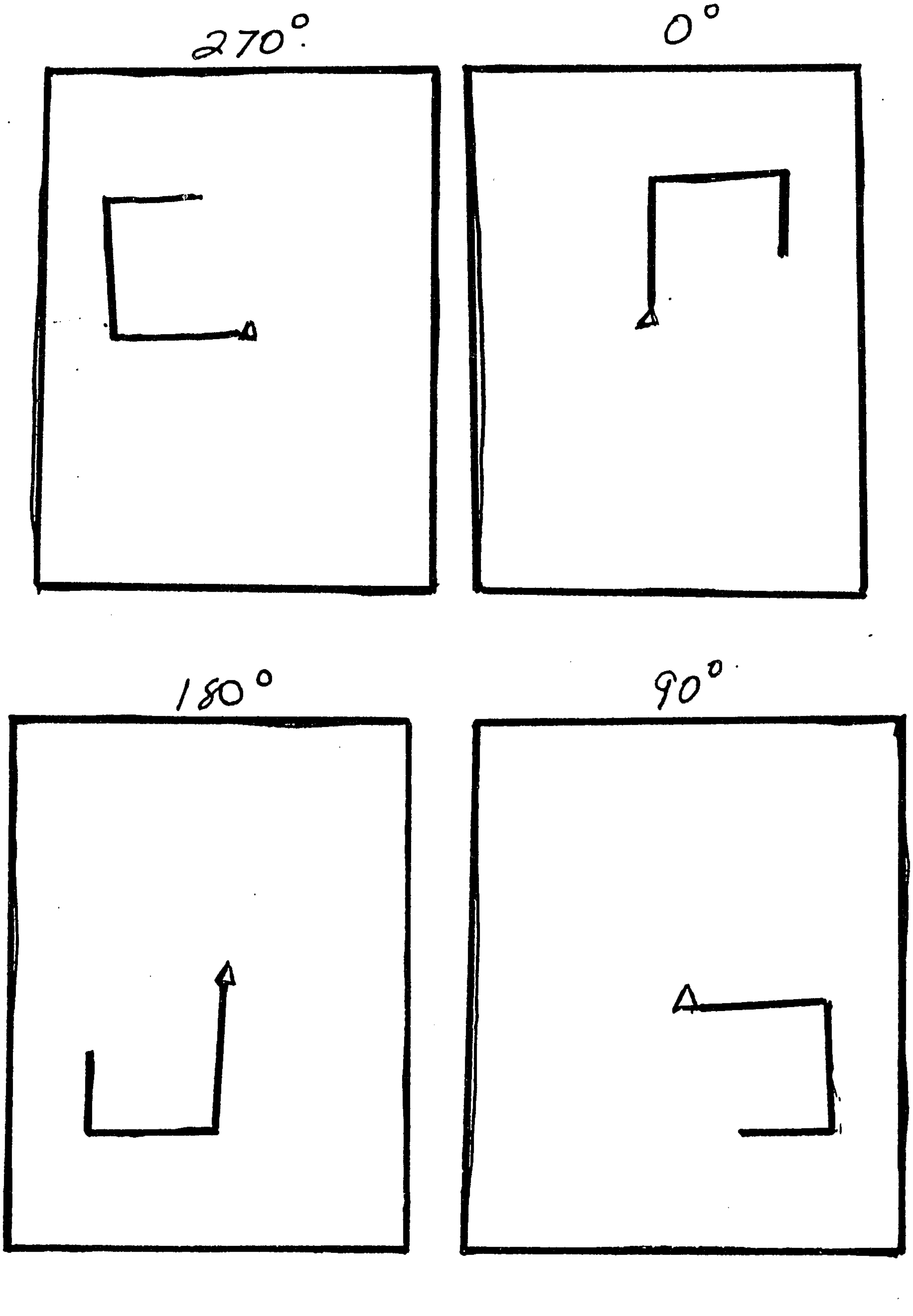


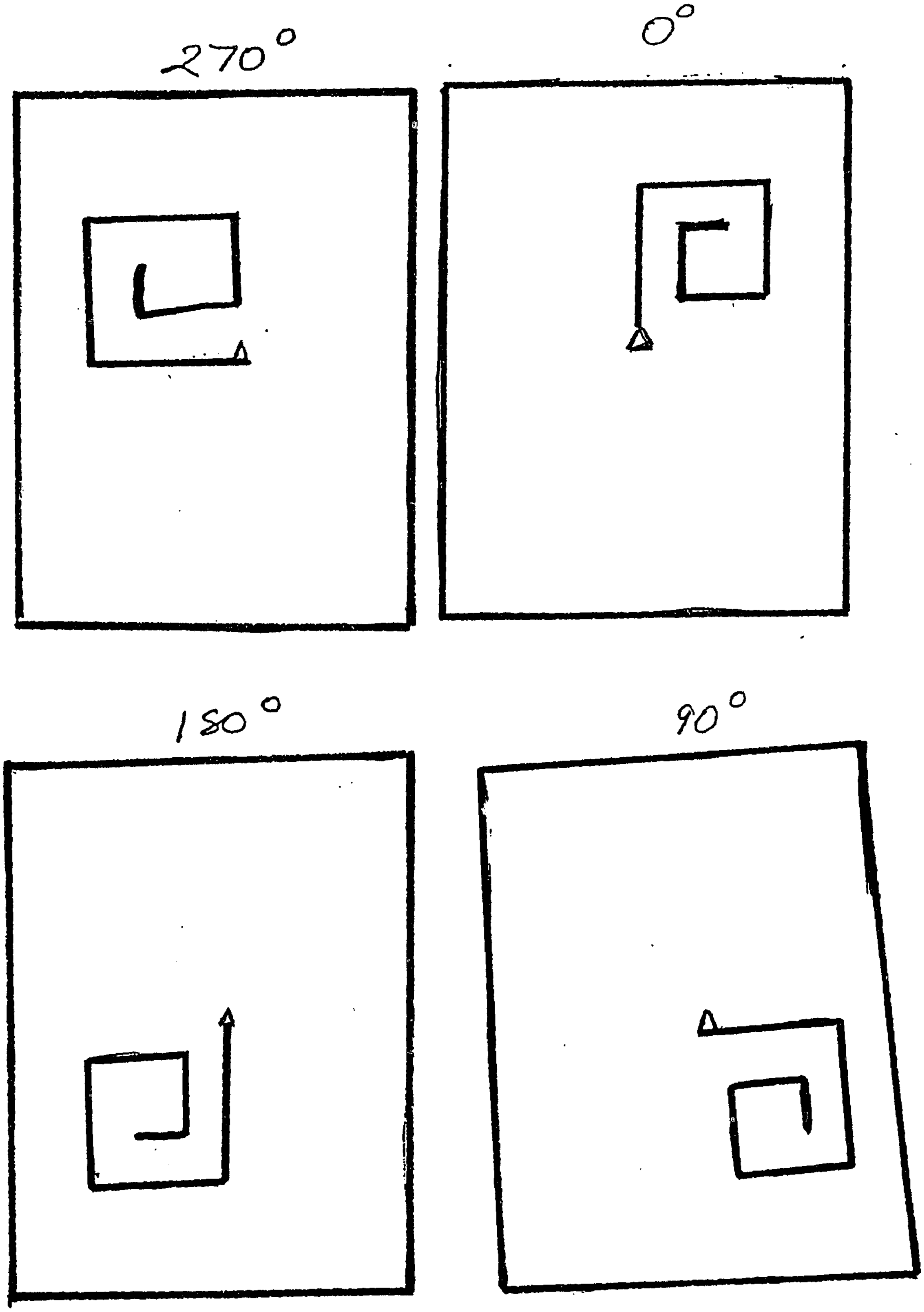
Figure 3

Appendix 7

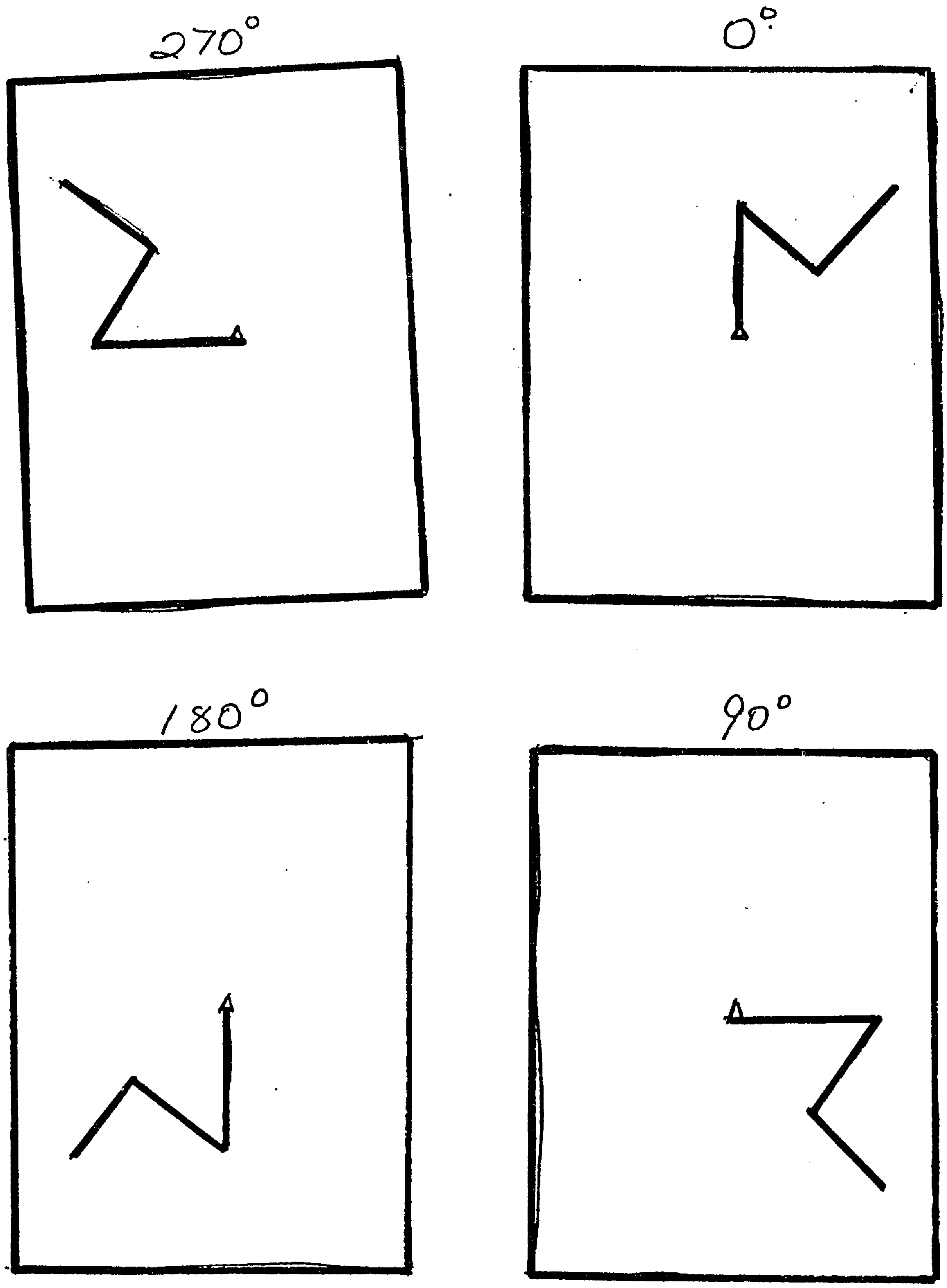
Problem Solving Exercise--Training



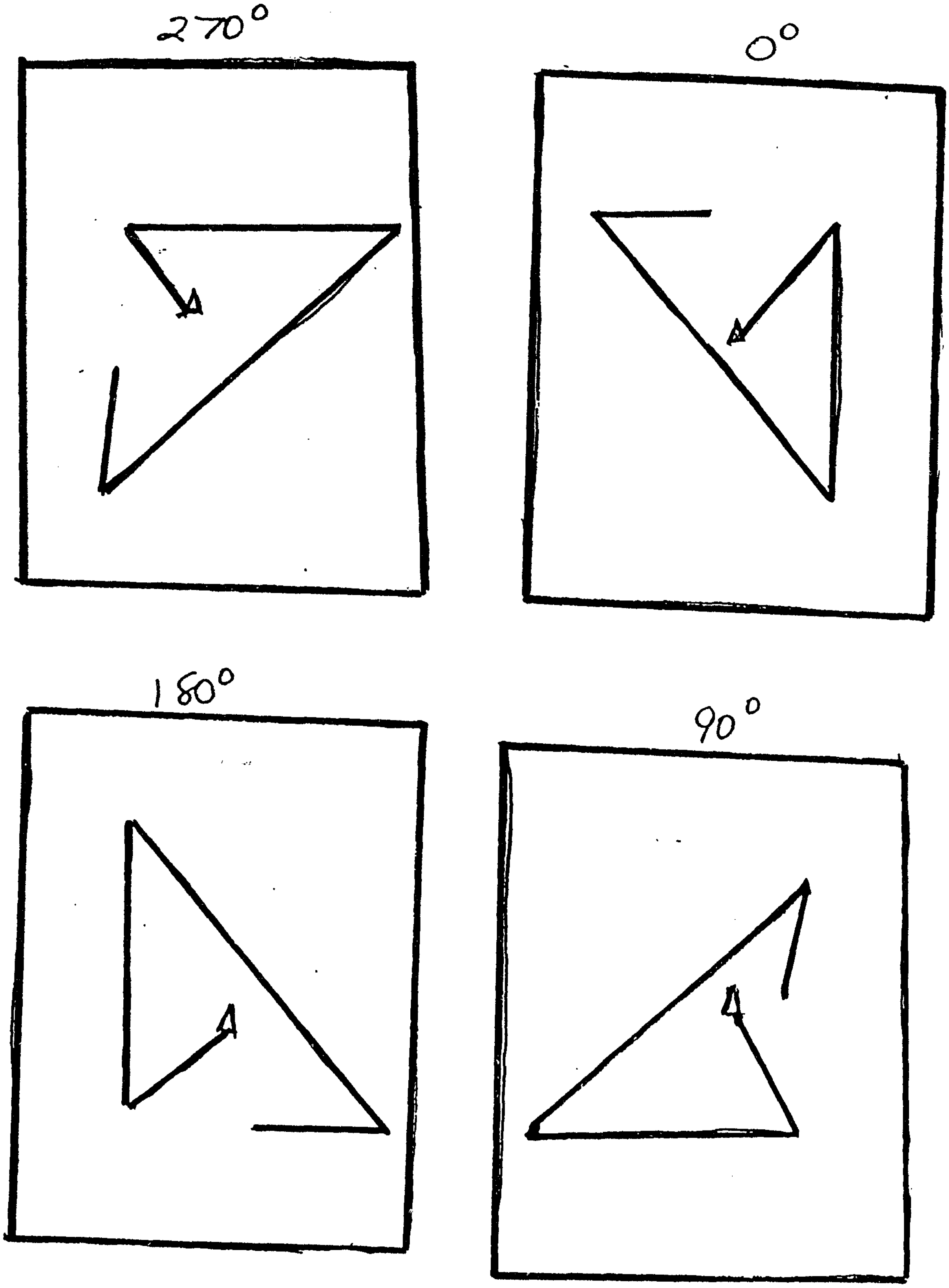
Appendix 8
Problem Solving Exercise 1
(90 Degrees Only)



Appendix 9
Problem Solving Exercise 2
(45 and 90 Degrees)



Appendix 10
Problem Solving Exercise 3
(45 Degrees only)



Appendix 11

A priori Keystrokes for Problem-Solving Tasks Training

0°		90°		180°		270°	
A	B	A	B	A	B	A	B
FD 20	LT 90	RT 90	LT 90	RT 90	BK 20	RT 90	LT 90
FD 20	LT 90	FD 20	BK 20	RT 90	BK 20	BK 20	FD 20
FD 20	BK 20	FD 20	BK 20	FD 20	BK 20	BK 20	FD 20
RT 90	BK 20	FD 20	BK 20	FD 20	LT 90	BK 20	RT 90
*FD 20	BK 20	RT 90	LT 90	FD 20	*FD 20	LT 90	RT 90
FD 20	LT 90	*FD 20	*FD 20	RT 90	FD 20	*FD 20	*FD 20
FD 20	*FD 20	FD 20	FD 20	*FD 20	FD 20	FD 20	FD 20
RT 90	FD 20	FD 20	FD 20	FD 20	RT 20	FD 20	FD 20
FD 20	FD 20	RT 90	RT 90	FD 20	FD 20	RT 90	RT 90
FD 10	RT 90	FD 20	FD 20	RT 90	FD 10	FD 20	FD 20
	FD 20	FD 10	FD 10	FD 20		FD 10	FD 10
	FD 10			FD 10			

* indicates the half-way complete mark.

Appendix 12

A Priori Keystrokes for Problem-Solving Tasks 1

0° A	0° B	90° A	90° B	180° A	180° B	270° A	270° B
FD 20	LT 90	RT 90	LT 90	RT 90	BK 20	RT 90	LT 90
FD 20	LT 90	FD 20	BK 20	RT 90	BK 20	RT 90	FD 20
FD 20	BK 20	FD 20	BK 20	FD 20	BK 20	RT 90	FD 20
RT 90	BK 20	FD 20	BK 20	FD 20	LT 90	FD 20	FD 20
FD 20	BK 20	RT 90	LT 90	FD 20	FD 20	FD 20	RT 90
FD 20	LT 90	FD 20	FD 20	RT 90	FD 20	FD 20	FD 20
FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	*RT 90	FD 20
*RT 90	FD 20	FD 20	FD 20	FD 20	*RT 90	FD 20	FD 20
FD 20	FD 20	*RT 90	*RT 90	FD 20	FD 20	FD 20	*RT 90
FD 20	*RT 90	FD 20	FD 20	*RT 90	FD 20	FD 20	FD 20
RT 90	FD 20	FD 20	FD 20	FD 20	RT 90	RT 90	FD 20
FD 20	FD 20	RT 90	RT 90	FD 20	FD 20	FD 20	RT 90
FD 20	RT 90	FD 20	FD 20	RT 90	FD 20	FD 20	FD 20
RT 90	FD 20	FD 20	FD 20	FD 20	RT 90	RT 90	FD 20
FD 20	FD 20	RT 90	RT 90	FD 20	FD 20	FD 20	RT 90
	RT 90	FD 20	FD 20	RT 90		FD 20	FD 20
	FD 20			FD 20		RT 90	
						FD 20	

* indicates the half-way complete mark.

Appendix 13

A Priori Keystrokes for Problem-Solving Tasks 2

0° A	0° B	90° A	90° B	180° A	180° B	270° A	270° B
FD 20	LT 90	RT 90	LT 90	RT 90	BK 20	LT 90	RT 90
FD 20	LT 90	FD 20	BK 20	RT 90	BK 20	FD 20	BK 20
FD 20	BK 20	FD 20	BK 20	FD 20	BK 20	FD 20	BK 20
RT 90	BK 20	FD 20	BK 20	FD 20	LT 45	FD 20	BK 20
RT 45	BK 20	RT 90	LT 45	FD 20	*FD 20	RT 90	LT 45
*FD 20	LT 45	RT 45	*FD 20	RT 90	FD 20	RT 45	*FD 20
FD 20	*FD 20	*FD 20	FD 20	RT 45	FD 10	*FD 20	FD 20
FD 10	FD 20	FD 20	FD 10	*FD 20	LT 90	FD 20	FD 10
LT 90	FD 10	FD 10	LT 90	FD 20	FD 20	FD 10	LT 90
FD 20	LT 90	LT 90	FD 20	FD 10	FD 20	LT 90	FD 20
FD 20	FD 20	FD 20	FD 20	LT 90	FD 10	FD 20	FD 20
FD 10	FD 20	FD 20	FD 10	FD 20		FD 20	FD 10
	FD 10	FD 10		FD 20		FD 10	
				FD 10			

* indicates the half-way complete mark.

Appendix 14

A Priori Keystrokes for Problem-Solving Tasks 3

0^{o}		90^{o}		180^{o}		270^{o}	
A	B	A	B	A	B	A	B
RT 45	LT 90	RT 90	LT 45	RT 45	LT 90	RT 90	LT 45
FD 20	LT 45	RT 45	BK 20	BK 20	LT 45	RT 45	FD 20
FD 20	BK 20	FD 20	BK 20	BK 20	FD 20	BK 20	FD 20
FD 20	BK 20	FD 20	BK 20	BK 20	FD 20	BK 20	FD 20
RT 90	BK 20	FD 20	LT 45	LT 45	FD 20	BK 20	RT 90
RT 45	LT 45	RT 90	FD 20	FD 20	RT 90	LT 45	RT 45
FD 20	FD 20	RT 45	FD 20	FD 20	RT 45	FD 20	FD 20
FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20
FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20
FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20
FD 20	FD 20	FD 20	RT 90	RT 90	FD 20	FD 20	FD 20
RT 90	RT 90	FD 20	*RT 45	*RT 45	FD 20	RT 90	RT 90
*RT 45	*RT 45	LT 90	FD 20	FD 20	LT 90	*RT 45	*RT 45
FD 20	FD 20	*RT 45	FD 20	FD 20	*RT 45	FD 20	FD 20
FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20
FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20
FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20
FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20
FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20	FD 20
FD 20	FD 20	FD 20	RT 90	RT 90	FD 20	FD 20	FD 20
RT 90	RT 90	FD 20	RT 45	RT 45	FD 20	RT 90	RT 90
RT 45	RT 45	RT 90	FD 20	FD 20	RT 90	RT 45	RT 45
FD 20	FD 20	RT 45	FD 20	FD 20	RT 45	FD 20	FD 20
FD 20	FD 20	FD 20			FD 20	FD 20	FD 20
		FD 20			FD 20		

* indicates the half-way mark.