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Logo mastery: Cognitive styles and problem solving strategies used by kindergartners and third graders

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LOGO MASTERY: COGNITIVE STYLES AND PROBLEM SOLVING STRATEGIES USED BY KINDERGARTNERS AND THIRD GRADERS

by

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Fifty-one third grade students and fifty-one kindergarten students enrolled in an elementary school were placed in either a field independent group or a field dependent group using a test of stylistic preference. Students first learned to maneuver in the Logo Microworld using the Syntonic Command Method. This method allowed students to position the cursor in eight different directional positions with a single keystroke. By selecting the appropriate color-coded directional "turtle key" students moved the turtle in the direction necessary to solve the problem. Only ten keys (eight turtle keys for directional heading and two forward move keys) were required for students to solve any on-screen problem. After demonstrating an acceptable level of mastery, students proceeded to problem solving strategies training. During training half of the subjects in each learning style group were randomly assigned to receive analytic training followed by relational training, while the other half of the students received training in the reverse order of presentation. The analytic training required the student to determine the one correct route that would move the cursor from its starting point to its destination in the shortest possible path. The relational training required the student to determine as many different

paths as possible to the destination within a two-minute time period. At the conclusion of each training session a 16-item LOGO Problem Solving Test was administered. Each test included eight analytic problems and eight relational problems presented in random order. Data analysis revealed the following: field dependent students performed as well as field independent students; kindergarten students performed as well as third grade students; and finally, all students performed equally well regardless of the order of training. However, results did show an interaction effect for order of training when students were grouped by developmental level and stylistic preference. Field independent kindergartners who were trained in the analytical problem solving strategy first did significantly better than field dependent third graders. Developmental level, stylistic preference, and the order of training had practically no significant effects on a student's performance. Furthermore, this study provided support for the viewpoint that age-appropriate Logo training schemes coupled with problem solving strategies prepared young children for relatively complex problem solving within a logo microworld.

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of the Graduate School at the University of North Carolina at Greensboro.

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CHAPTER I

BACKGROUND

Computer technology has introduced new challenges into the classroom, challenges being met with mixed reactions by teachers (Watson, Calvert, & Brinkley, 1987). Although educators and researchers are especially interested in the cognitive benefits of computer programming (Clements & Gullo, 1984; Emihovich & Miller, 1986; Watson, Lange, & Brinkley, 1992), debate continues regarding the merits of computers as traditional teaching methods. In particular, the computer's effectiveness and efficiency are being questioned. Classroom innovations must take into account individual student learning characteristics, a teaching-learning style match between educators and students (Dunn, 1984), technological innovations, and the general social context of learning (Emihovich & Miller, 1986). Seldom, if ever, has the cognitive style of the student been used as a criterion for determining the compatibility or suitability of educational programs.

Steffin (1983) stated that "children quickly learn to shape their problem-solving processes in the direction of finding an 'approved' response by the most expedient route possible" (p. 255). Therefore, children first learn that cognitive problems have only one correct answer. Steffin took the stand that computers may assist in breaking this early formed response pattern (strategy) by pointing out the unique quality of human and machine interaction. The computer requires interaction between the student and the information presented. Therefore, students are forced to be active participants in the management of their own learning. Students should no longer passively absorb information presented to them.

This active participation is what Seymour Papert had in mind for young students learning to problem solve with a microcomputer. He developed the software 'LOGO' specifically with interactive capabilities (Papert, 1980). Logo is described as a language that is accessible for very young students while being open-ended and challenging for older students. Young students use Logo's turtle graphics as a way to program an on-screen microworld. Older students use turtle graphics to write their own programs instructing the turtle what to do on-screen. When using Logo, students young and old make decisions, watch those decisions being carried out on-screen, and take the opportunity to correct mistakes or "debug" problems, thus understanding and truly learning from their mistakes. Therefore, Logo has no right or wrong answers, and there are endless possibilities when learning within a microworld.

Whether a response is correct or incorrect is just as important as understanding how a student achieved a particular performance (Hunt, 1980). How a student achieves a particular performance is thought to be guided by stylistic differences, i.e. convergent or divergent thinking. Witkin, Moore, Goodenough, and Cox (1977) defined cognitive styles as the characteristic approach which encompasses both perceptual and intellectual activities that the person brings with him/her to a wide range of situations. Steffin (1983), however, specifically thought of cognitive style as either convergent thinking or divergent thinking. Steffin characterized convergent thinking as a set of "correct" responses containing one element. In addition, the solution set of "correct" responses originates from a specific subject being addressed; as such, the primary cognitive process required is recall or recognition memory. Divergent thinking is characterized as a set of "correct" responses containing more than one element. The solution set of "correct" responses functions through a set of criterion which differentiates it from the "not correct" responses, therefore demands an application of various skills from the student. Saracho (1984) believed "If educational programs are to be effective, it is essential that students' learning styles are matched to instructional elements" (p. 46). Therefore, it is also crucial that careful consideration be given to how the computer is used in the classroom.

The problem is that only limited research data exists regarding the quality and quantity of microcomputer applications. At present, there are few answers to questions which ask just how beneficial the use of microcomputers are.

Purpose of the Study

The purpose of the present study was to examine the cognitive styles and problem solving strategies used by kindergartners and third-graders within Logo. Particularly, this study was designed to examine how order of training in two different problem solving strategies (analytical and relational) would affect the student's use of the two strategies. In order to address the above concerns, several distinct, relevant bodies of literature were discussed. However, before a review of relevant literature, several key terms were defined.

Definition of Terms

1. _Cognitive style_ refers to individual variations in patterns of processing information in perception, memory, thought, and judgment (Kogan, 1983).

2. _Logo programming_ refers to the computer language developed by Seymour Papert which allows young children to program a computer using a triangle cursor known as a "turtle."

3. _Spatial skills_ refers to demonstrated ability to recognize and recall certain spatial constructs such as routes and landmarks (Siegel, 1978) and to use one's understanding of their meaning to solve problems on a microcomputer.

Hypotheses

1. Field Independent students will do significantly better on the analytic portion of the Logo test.

2. Field Dependent students will do significantly better on the relational portion of the Logo test.

3. Third grade students will do significantly better than the kindergarten students overall.

4. Third grade Field Independent students will do significantly better than any other group of students.

5. Kindergarten Field Independent students will score as well as Third Grade Field Dependent students on the analytic portion of the Logo test.

6. Students who are first trained on methods matching their stylistic preferences (field independents on the analytic/relational method and field dependents on the relational/analytic method) will do significantly better than will students trained on nonmatching stylistic preferences.

CHAPTER II

REVIEW OF THE LITERATURE

Microcomputers

Drill and practice seem to be the primary microcomputer based application in education (Hagen, 1984; Laskey, 1984; Torrance, 1981). The repetitive drill and practice presentational technique produces overlearning as a way to acquire needed factual information (Hannaford, 1983). Concepts are presented, and then covered an additional number of ways to reinforce what was taught until a prescribed level of performance is reached. While its benefits are acknowledged, there is the potential for the development of poor quality software becoming little more than an "electronic workbook" (Laskey, 1984; Torrance, 1981). Thus properly designed instructional material has been noted as a high priority for effectively using the microcomputer to assist in learning.

A variety of software formats have been developed; however, several features are considered essential principles of programmed instruction (Lerner, 1972). For example, adequate computer design should be built around specific goals that address defined skills and should be organized to branch progressively in coherent and hierarchical sequence (Caldwell, 1980; Hannaford & Taber, 1982; Lerner, 1972). Withrow et al. (1986) considered multiple levels of difficulty as essential, while others (Caldwell, 1980; Hannaford & Taber, 1982; Wagner, 1981) cautioned that the compatibility of the topic with a cognitive skill level required for the task, needs to be given careful consideration.

Good instructional design considers presentation of the material in terms of clarity of stimuli, directions, length, and modality of presentation. Multisensory programs are considered best in terms of motivation and adaptability and are highly praised for using appropriate text, graphics, and sound in their presentation (Caldwell, 1980; Hannaford & Taber, 1982; Laskey, 1984). In terms of choices, explanation, and commands, Laskey (1984) and Shearer (1984) described "user friendly" instruction as being simple and easily enough understood for the program to run smoothly. Feedback and reinforcement are the keys to adequate design and there is general agreement that immediate and clear feedback which is positively reinforcing is imperative (Bennett, 1982; Caldwell, 1980; Hannaford & Taber, 1982; Laskey, 1984).

The issue of quality software has been a topic of considerable discussion and the basis for questions related to appropriateness, functionality, and quality issues.

Bates and Wilson (1984) and Hagen (1984) caution that sources for finding quality software are still limited and a review of both commercial and research literature support their belief. Hofmann (1985) further questioned whether software designs appropriately incorporated theories of learning or cognitive development. In an attempt to accelerate acquisition of skills, software packages often present information that children are not cognitively ready to use in a meaningful way. Logo, however, is thought to be a developmentally ready software that children can explore in a meaningful way (Papert, 1980).

Logo

Logo offers children a "learning environment" and a means to self-discovery (Papert, 1980). Logo was designed to introduce children to programming concepts, and through Logo programming, to concepts that develop higher order thinking skills that transfer to other contexts (Pea & Sheingold, 1987). The philosophy behind Logo is that it allows children to interact with the microcomputer as a learning tool, to be in charge of the environment known as a microworld, and to encourage self-direction rather than merely react to preprogrammed software. The environment is that of "Turtle Geometry" or "Turtle Graphics" which uses a small triangular cursor that the child controls. The turtle moves in four directions: forward, backward, left, and right. Distance is added by combining numbers with the directional command. Forward 30 moves the turtle thirty turtle steps. Turning right or left is done by the entry of degrees; right 90 rotates the turtle ninety degrees to the right. Logo's discovery learning environment provides endless opportunities for problem solving and creation of self-expression. The child in effect is the teacher. The computer knows nothing unless the child tells it what to do. Everything the turtle does is under the control of the child, in movement, in language used, and in directing the turtle's activities. Logo allows children to build on the experiences they encounter in a microworld. Seymour Papert (1980), the creator of Logo, suggested that among many other experiences, using Logo enables young children to develop spatial skills, such as rotating an object helps the child to determine relationships between two or more objects in space.

Logo gives children the opportunity to discover. As children direct the turtle and begin planning the next steps, they develop an understanding of cause and effect. Therefore, working with learned commands can lead to adjustments that will achieve the desired effect. For these reasons Logo has been proclaimed to stimulate thought process and reasoning/problem solving skills (Hagen, 1984).

Logo, Preschoolers, and Kindergartners

Papert (1980) is credited with generating interest as well as research concerning how microcomputer programming may be used to train children's thinking and problem solving (Brinkley & Watson, 1988; Brinkley & Watson, 1989/90; Brinkley & Watson, 1990/91; Clements & Gullo, 1984; Emihovich & Miller, 1986; Pea & Kurland, 1984; Shade, Nida, Lipinski, & Watson, 1986; Watson & Brinkley, 1990/91; Watson et al., 1992). Several studies (Brinkley & Watson, 1988; Brinkley & Watson, 1989/90; Brinkley & Watson, 1990/91; Clement & Gullo, 1984; Emihovich & Miller, 1986; Papert, 1980; Shade & Watson, 1987; Watson & Brinkley, 1990/91; Watson et al., 1992) showed that preschoolers and school-age children are able to learn certain Logo concepts. Children as young as three years of age were found to successfully operate difficult software (Shade & Watson, 1987) and learn "sorting" behaviors (Brinkley & Watson, 1988).

Research by Emihovich and Miller (1986) investigated young children's metacognitive skills (self-monitoring, evaluation of one's own knowledge) in order to explain qualitative changes in young children's Logo learning. They found that mediated training in Logo instruction had a positive effect on children's monitoring behavior during a task presumed to be too difficult for their age. Also, the analyses indicated that, over time, children learned to respond to the teacher's cues about what should be done next. Thus, learning metacognitive strategies further allowed the teacher to "teach"less and provide more evaluative feedback to the children about their performance. Emihovich and Miller concluded by pointing out that children's learning with Logo should reflect Logo as a "context" for learning rather than Logo as simply a tool for learning (1986).

The Children and Technology group at the University of North Carolina at Greensboro completed a series of research studies designed to investigate the relationship between cognitive style, microcomputer programming, and teacher/student strategies most appropriate for working with microcomputers (Allen, 1992; Brinkley & Watson, 1988; Lipinski, Nida, Shade, & Watson, 1986; Shade et al., 1986; Shade & Watson, 1987; Watson, Calvert, & Popkin, 1987; Watson, Chadwick, & Brinkley, 1986). Results from these studies showed that young children can successfully program in Logo, prefer certain strategies, can be taught successful strategies, construct overarching, age-appropriate theories, and have stylistic preferences (Watson & Busch, 1989; Watson et al., 1992).

Allen (1992) examined stylistic preference as it affected the Logo problem solving performance of a group of minority preschoolers. Sixteen minority preschoolers, following pretesting and classification to stylistic preference, were trained on how to maneuver within a Logo microworld using the syntonic command method developed in a study by Howard, Allen and Watson (in press). Each preschooler was then tested for maneuverability mastery on ten keyboard commands. The preschoolers received two types of problem solving strategy instruction. Following each instructional session, the preschoolers were given a Logo problem solving test which consisted of 8 analytic and 8 relational items. It was concluded that there was no significant performance differences on either the analytic or relational portions of a Logo problem solving test with regard to stylistic preference or the order of training received. In addition, the study provided evidence that neither intensive nor extensive training was necessary for minority preschoolers to successfully maneuver with a Logo microworld. Allen did show that having color coded directional keys on the keyboard and corresponding positions attached to the edges of the computer (which was a design feature of the syntonic command method), provided "external environmental cues" that allowed the preschoolers to work within the microworld with ease. Allen stated that preschoolers were assisted in making path solution decisions by viewing previously charted paths (charting a new path in a different color by way of a reappearing turtle cursor) while continuing to maneuver within the same microworld. Allen did, however, state that the way the questions were presented to the preschoolers may have masked any differences. All children are more familiar with being asked analytical questions which require a single correct response. In addition, Allen reported that the preschoolers in the study were intent on achieving the goal of getting the turtle to the target, yet upon completion were not motivated to find alternative paths regardless of the time remaining.

Cognitive Styles: Field Dependence and Field Independence

Witkin, Goodenough, and Karp (1967) referred to Field dependence - Field independence (FDI) constructs as the tendency to perceive an object in space with or without regard for the background. Field dependence implies a reliance on information from the background to process information. In contrast, field independence refers to a tendency to perceive an object in detail without having to rely on information drawn from the background.

Goodenough (1976) found that field dependent children tend to perform poorly on cognitive restructuring tasks, use non-self referents to process information, show greater interest in concrete versus abstract thinking, and tend to rely on others for assistance and structure. Field independent children tend to exhibit greater cognitive restructuring by using internal referents to process information, demonstrate a higher degree of interest in abstract and theoretical ideas, and tend to behave more autonomously in relation to others. In addition, field independent children show particular strengths relative to cognitive skills while field dependent children show particular strengths relative to interpersonal competencies (Kogan, 1983).

Spatial Development

The concepts of left and right have been explored and reported in the literature since the early 1900s in both theoretical and experimental contexts; however, it was Piaget (1926, 1928) who first systematically studied how children develop the concept of space. Beginning with his early investigations Piaget proposed very definite stages in the evolution of left and right discrimination. He explained the process as a gradual socialization of thought which progressed in stages from egocentrism, to socialization, and to complete objectivity.

Rather than adopting Piaget's (1926) interpretation of decreasing egocentrism with age, Benton (1959) referred to other intellectual characteristics such as abstract reasoning, visual imagery, and symbolic formulation to explain left-right discrimination. In addition, Benton found that the development of verbal intelligence was concurrent with knowing one's left-right, while age and conceptualization of the human figure are connected with using the labels (left and right) on oneself. Similarly, Lacouriere-Paige (1974) agreed with Benton's (1959) findings and proposed correlating age and intellectual abilities with children's ability to learn left and right. Benton and Swanson (1985) devised an extensive test battery which required children (first with their eyes open and then with their eyes closed) to point to their own body parts as well as parts on a pictured person. Results showed a progressive development in discrimination skills through the ages of six to nine years. Although Benton and Swanson found no discriminating effect, their findings suggested that the ability to discriminate left from right with respect to another person, i.e. the ability to reverse one's own point of view, emerged after the age of eight years.

In an extensive analysis of cognition and space, Piaget and Inhelder (1967) assigned stages in the development of children's concepts of space. They suggested that intellectual understanding of space begins to emerge at age two, following the sensorimotor stage. Piaget described this slow but progressive development in early childhood from sensorimotor space through preoperational (2-7 years) to concrete operational space (about 7 years) where children acquire sufficiently flexible mental operations for some symbolic thinking.

Piaget and Inhelder (1967) went on to describe developmental stages for learning spatial concepts beginning at about age 2 with topological space. Gradually, projective and Euclidian operations evolve as spatial concepts continue to be refined and elaborated. Topological space is the more concrete perception of relationships in space. At this elementary stage, internal properties of an object are the concern rather than the relationship of the object to anything else (Piaget & Inhelder, 1967). Beginning at about age 4 and completed at about age 7, projective space adds new characteristics to topological space. The system for locating objects in relation to each other emerges here, as viewed from the perspective of the observer. Euclidian space forms an overall reference system for coordinating horizontal L-R, front-back, and vertical up-down. Euclidian relations consider an object in relation to other objects within a stable framework. Following the chronological evolution of topological, projective, and Euclidian representations, the concepts of left and right constitute part of projective space (Piaget & Inhelder, 1967). When projective (and Euclidian) relations are added to topological space, objects are able to be considered from the observer's point of view.

Logo, Spatial Development, and Young Children

Fay and Mayer (1987) tested young children's use of Piaget's egocentric concept in a study of spatial references. Fay and Mayer found that young children use the Logo turtle cursor in a "turtle-centric" fashion. When a child thinks "turtle centrically" the child refers to right as in reference to the turtle's right rather than the child's own right. Thus children use language to interpret what Logo commands mean, for example RT 90 means to turn right and move 90 steps. Campbell, Fein, Scholnick, Schwartz, and Frank (1986) investigated kindergartners' coding of four instant Logo positioning commands. Their results showed that children's mastery of Logo improved over time both in terms of verbalizing control strategies and in control of the turtle. Also, it was found that forward moves were more accurately coded than back or left moves and that right turns were favored more than left turns. Mayer and Fay (1987) investigated three specific changes that developed as children learned Logo. First children learned syntax--what command keywords are and what these words mean. Then the children learned to think semantically, that is, understanding that a "right" turn always means the "turtle's" right versus right of the computer screen. Last, the children learned to transfer skills to non-programming contexts. Mayer and Fay concluded that children do experience a series of cognitive changes as they learn to program in Logo and "under appropriate conditions, learning to program can modestly influence children's thinking in areas similar to those involved in programming" (1987, p. 278).

Watson et al. (1992) investigated young children's spatial problem-solving abilities viewed from a stylistic perspective by providing a Logo spatial learning environment in which young children could act out solutions to prepared problems. In the first three phases of their study, the children used Logo to learn programming and to demonstrate direct and indirect route strategies. In the final phase a miniature village and computer-controlled robotic turtle were used to investigate whether the children could transfer their knowledge of on-screen Logo and direct/indirect route strategies to a real world problem. In phase one, children were taught ten positioning commands: forward, backward, right, left, big step, little step, big turn, little turn, pen-up, and pen-down. In the second phase (direct route strategy) of the study, it was found that "top-down, left-side, or right-side perspective caused confusion with left and right movements until other perspectives were learned" (p. 9), but was alleviated by phase three training (indirect route strategy). It was concluded that preschoolers were able to show the cognitive changes suggested by Mayer and Fay (1987) by demonstrating learned transfer skills to a non-computer screen task after three weeks of Logo training.

Brinkley and Watson (1989/90) in the first of a three-part study hypothesized that preschoolers used syntonic learning to manipulate the turtle in the direction of the target destination while using three distinctly different types of cursors: triangular, cross-shaped, and circular. Syntonic learning was defined as learning which is relevant and meaningful to the children's sense of what is normal and important in their environment. Syntonic learning allowed the children to determine the turtle's heading by using their own body gestures (i.e. pointing, turning themselves) as directional cues (Papert, 1980). Brinkley and Watson found that the children used the heading of two of the cursors (triangular and cross-shaped) to point toward the target destination. Since the children had the least success with the circular cursor, as was anticipated, strong support was gained for the pointing strategy as an early processing skill in Logo mastery.

In the second study, Brinkley and Watson (1990/91) continued research started by Brinkley and Watson (1989/90), Campbell, Fein, Scholnick, Schwartz, and Frank

(1986), Fay and Mayer (1987), Watson and Busch (1989), and Watson et al. (1992), which showed that children use the Forward, Right, and Big positioning commands more often and that Forward is the more frequently used command. A common research question asked was

> When children initially begin to problem solve with Logo, do they show more success with problems in the top half over the bottom half of the microcomputer screen, the upper right over upper left, lower right, or lower left quadrants, forward over backward moves, and right over left turns? (p. 77)

Generally, data from these studies showed that children's problem solving strategies when initially learning Logo are pointing, moving forward, turning right, and using big moves mostly in the upper right quadrant. Brinkley and Watson concluded that after these initial strategies were mastered children then conceptually divided the screen into upper and lower halves, quadrants, concentric circles, and finally they used references that were turtle-centric in nature.

In the third and final part of the study, Watson and Brinkley (1990/91) investigated space and premathematic strategies of young children by asking

> When solving a planned sequence of Logo training and transfer problems: (a) will young children show a significant preference for a right turn strategy over left turns? and (b) will young children show a significant preference for big step strategy over little steps? (p. 19)

It was found that young children would indeed follow through on a two-category decision process which was a choice between a big step (30 turtle steps) or a little step (10 turtle steps). Their findings confirmed Papert's theory that syntonics and pointing strategies are ways in which young children manipulate Logo space in an informal manner without necessarily understanding the complex concepts of right and left or even a formal number system.

Third Graders and Logo

Roach (1988) compared the effects of two instructional strategies for teaching Logo problem solving skills to 49 third graders. The two strategies used were: (1) the guided discovery approach - a student-directed learning environment with the teacher as a facilitator and (2) the direct instruction approach - with specific teacher-directed activities being used to teach direct transfer problem solving skills. In addition field dependence/field independence stylistic differences were investigated along with the development of problem solving skills through the use of the two instructional strategies. Roach found that Logo instruction did improve problem solving skills regardless of instructional method. However, the students' cognitive style did not affect their ability to gain problem solving skills when compared by method.

Lee (1991) investigated the metacognitive and cognitive effects of different loci of instructional control and prior background knowledge on 62 third graders. The metacognitive effects were defined as utilization and correctness of metacognitive monitoring and the cognitive effects were defined as knowledge acquisition and application. In addition, Lee explored the effectiveness of the strategies used by the learner while under instructional control and a learner's prior knowledge as one element of individual differences among students. Logo and two versions of a Computer Assisted Instruction (CAI) program were used in the study. A pretest was developed and used to assess students' prior background knowledge of math, patterns, angles, and directions. Students were then randomly assigned to either the learner control (Logo) or the program control (CAI) group. Before the lessons began, a training period was given to the students to acquaint them with the objectives, procedures, and values related to the use of the instructional programs. The students were posttested on (a) knowledge acquisition and application and (b) knowledge application. In testing for the assessment of knowledge acquisition 20 items similar to the practice items in the lessons were presented to evaluate the students' ability to recall commands taught throughout the study. For the assessment of knowledge application, the students were given the dimensions of each side of a square on the screen and asked to draw the square by entering Logo commands. Finally, students were interviewed using mathematically incorrect story questions with prompt questions to assess their metacognitive monitoring. Lee's study showed that under learner control the students became responsible for their own learning, demonstrated conscious reflection on their cognitive abilities, task demands, and learning strategies, and learned how to manage their own thinking and learning activities. In addition, in the area of background knowledge Lee reported that students' prior knowledge of concepts relevant to those being taught were important in understanding the underlying structure of the instruction and in the development of effective learning strategies. Overall, students in the learner control group showed significantly better performance than did those in the program control group in both metacognitive and cognitive effects, regardless of individual differences or prior background knowledge.

In the first of a three-part study Lehrer and Smith (1986a) contrasted the effects of mediated, intensive Logo instruction with less-intensive, discovery-oriented instruction on third-graders. Their research was specifically designed to answer the ongoing questions of (1) whether Logo instruction transfered to other context that involve applications of general problem-solving skills; (2) whether Logo instruction served as an analogical bridge to performance in other related areas; (3) whether Logo instruction transferred spontaneously to a metacognitive task; and (4) whether Logo instruction helped students restructure their knowledge of geometry. The control group received formal instruction in Logo once a week for 9 weeks, 45 minutes each week, having access to only one computer for 12 weeks. It was believed that this was a typical scenario for most elementary schools using computer based instruction. The students given the mediated instruction (the experimental group) received 31 sessions of 20-25 minutes each in pairs for 12 weeks. This group had access to 4 microcomputers with each student participating an average of 60 computer sessions. Instruction was presented in the context of projects that blended student initiative and instructor suggestions in a guided-discovery approach. Programming projects included introduction to programming, estimation of length as a standard unit of measure, Logo graphics, estimation of angles and distance, use of variables, work-space management, procedures to create polygons, and applying an heuristic decomposition problem model - IMDC to solve problems in Logo. The IMDC model referred to (1) Identify parts, (2) Make procedures for each part, (3) Decide on how the procedure relates, and (4) Compose the whole. Results indicated that mediated instruction was a prerequisite for the transfer of Logo knowledge to other areas. However, there was little evidence of general problem-solving skills transfer. The Logo experience overall appeared to contribute to the development of monitoring the relationship between new and previously learned information.

In the second study, the mediated (guided-discovery) approach to Logo instruction was extended to encompass two distinct instructional goals. The students in goal group one received mediated instruction in how to apply a previously presented heuristic decomposition problem model, IMDC to solve a variety of problems, therefore, using the mediated instruction as a tool to problem solve in Logo. The students in the goal group two used Logo as a tool for understanding concepts of geometry. The questions asked in this study were: (1) whether Logo instruction transferred to other contexts that involve applications of general problem-solving skills; (2) whether Logo instruction influenced problem description in a novel context; (3) whether Logo instruction transferred spontaneously to a metacognitive task; (4) whether Logo instruction helped students restructure their knowledge of geometry, and (5) whether the acquisition of Logo instruction is related to mathematics ability in short-term memory or working memory. As in the first study, the instructional goals were presented within the constraints of the problem and the students were encouraged to elaborate on their description of the problem. Lehrer and Smith found children instructed in Logo appeared to describe problem constraints more adequately than did their peers in geometry group. In addition, these students solved a planning task with fewer moves. Results were mixed regarding metacognition. Students in goal group one (mediated instruction) demonstrated enhanced monitoring skills while students in goal group two did not demonstrate similar benefits. The strongest results overall involved the use of Logo as a tool to restructure the student's understanding of geometry. Furthermore, a relationship between Logo and a higher level of understanding of the concepts of plane geometry was found. Lehrer and Smith also reported that the students general mathematical ability and their working memory were both predictors of Logo acquisition. However, as with the first study, the Logo based learning was found to be nontransferable to general problem-solving skills.

In the final stage of their three-part study, Lehrer, Randle, and Sancilio (1988) further investigated the relationship between the development of geometric concepts and Logo instruction. Operating on the assumption that to use Logo as a tool, one must know Logo, these researchers randomly assigned 32 fourth-graders who had participated in the previous study to one of two instructional groups. All students learned geometric facts while matching instructional goals and techniques. The students in group one used Logo to develop procedural representations of geometric facts, such as transforming properties of geometric figures using turtle dimensions. The students in group two, however, used conventional tools, such as protractors and rulers to develop procedural representations. It was hypothesized that there would be no instructionally related differences for knowledge of geometric facts due to both groups receiving identical knowledge instruction. It was also hypothesized that students in the Logo instruction group would learn more by doing, because Logo instruction offered more opportunities to develop associated representations (factual, procedural) of geometric concepts. As expected, Lehrer et al. (1988) found no differences between instructional groups with respect to geometric knowledge acquisition. However, differences were observed between instructional groups with respect to knowledge application.

Throughout their three-part study, one result continued to appear: that Logo-based instruction was found to help students establish a relationship between the observed properties of figures and the actions necessary to construct those figures. It was demonstrated, again in all three studies, that Logo could be used as a tool to restructure students' understanding of geometry. Furthermore, individual differences in knowledge of Logo instruction corresponded to individual differences in geometric concept knowledge even when mathematical ability was accounted for statistically.

Logo and Grade Comparisons

Clements and Gullo (1984) stated that

> because LOGO was designed to encourage children to reflect on how they think, programming should lead them to develop metacognitive abilities, especially the ability to realize when they do and do not understand instruction. (p. 21)

This belief led Clements (1986) to assess metacognitive processes while investigating the rationale for using Logo to develop metacomponential abilities in elementary school students. Seventy-two first and third graders were randomly assigned to one of three groups: Logo instruction, Computer Assisted Instruction (CAI) comparison and control. The students in the Logo group first spent several sessions learning the basic commands in a way that guided them to plan a program for the turtle to draw. Next, these students were directed to use a pictorial flow-chart to plan superprocedures, then to subdivide these into subprocedures by; (1) tracing each basic shape, known as a part, with tracing paper; (2) defining each part as a Logo procedure using support programs; (3) watching the procedure being executed by the turtle, and (4) editing it at any time. These steps led students to develop their own major projects through writing increasingly complex programs. The CAI group worked in pairs with various CAI software programs, while the control group worked in pairs and on regular classroom tasks. To investigate the student's metacognitive interactions a naturalistic observational procedure was employed. While the students worked in pairs recordings were made on occurrence and nonoccurrence target behaviors at intervals of 10 seconds. Target behaviors were defined as: (1) deciding what the problem was and what it required; (2) selecting how to solve the problem and what components to use; (3) sequencing the selected components; (4) monitoring progress; (5) deciding how much time to spend on each component, and (6) executing the task. Clements reported no developmental differences across metacognitive components, concluding that first and third graders performed equally on the observed target behaviors. However, Clements did find that students in the Logo group exhibited a higher frequency of target behaviors indicative of metacognitive processing abilities, while students in the CAI group spent more time responding to the program's feedback and performing the task required. Overall, the results showed that the Logo group significantly outperformed both the CAI and Control groups on deciding what the problem was and on the solution process. Clements believed that this investigation indicated that Logo was more efficient in developing the metacomponents of deciding what the problem is and selecting a solution, because in programming students must develop ideas for their own projects, present these ideas as a goal, and identify specific problems included in achieving these goals. Thus, Logo constitutes an effective environment for developing these metacognitive abilities.

Fay and Mayer (1987) believed that students arrive at the Logo environment with naive conceptions and confusions about spatial reference. With this assumption in mind they examined the naive conceptions of spatial reference (egocentric conceptions of space and undiscriminated conception of commands) and naive confusions (confusing left vs. right and confusing 45 vs. 90 degree angles) that students bring to a Logo learning environment. The focus was on two naive conceptions and two naive confusions of spatial reference. The naive conceptions were: (1) an egocentric conception of space defined as when a student defines right and left with respect to his or her own body or the screen rather than with respect to the turtle, and (2) an undiscriminated conception of commands defined as a student lacking in a scheme for discriminating two components of navigation, specifically turning and moving. The naive confusions were: (1) left-right confusions defined as occurring when a student fails to distinguish between left and right, and (2) argument confusion defined as occurring when a student fails to distinguish among numbers of degrees. Fourth, fifth, sixth, and eighth graders were introduced to six Logo commands, then tested on predicting the output for four instances of each of the commands. Each of the student's prediction responses were categorized into one of six conceptions. Fay and Mayer found, as expected, that older students performed better than younger students with regard to initial understanding of Logo commands. Also, as expected for younger students, turn commands were more difficult than move commands. Fay and Mayer believed that this result suggests that students' perceptions about turn instructions conflicts with the concepts necessary for learning Logo successfully. Furthermore, they posit that the concept of turning was not intuitively clear to students below the sixth grade. In addition, this study demonstrated that performance, as expected, was lowest when the turtle was headed at 180 degree orientation (the turtle pointing to the bottom of the screen) and highest when it was headed at 0 degree orientation (the turtle pointing to the top of the screen), suggesting that under certain conditions younger students were unable to take on perspectives other than their own. Overall, their investigation established support for the idea that elementary school age students entertain preconceptions about spatial reference that appear to conflict with the fundamental concepts of Logo.

Easton and Watson (1992) investigated stage of cognitive development, stylistic preferences, and strategy usage while testing levels III - V of the Watson Busch Model of Learning Logo on second and fifth grade students. It was hypothesized that

> field independent children would do significantly better than field dependent children on all test card sets and that second grade field independents would do better than either second or fifth grade field dependent students on all card sets. (p.7)

It was also hypothesized that card set 1 of the problem-solving test would produce fewer keystrokes and shorter task completion time and that card sets 2 and 3 would be increasingly more difficult. Finally, it was predicted that

> problems which occurred in the upper right (0 degree) quadrant orientation would be significantly easier with which to problem-solve than would be tasks in the lower left (180 degree) quadrant. (p. 7)

Each student received four Logo command training sessions, then a command training test, and finally a three-set problem solving test.

When testing the hypotheses, Easton and Watson found that field independent students did perform significantly better than field dependent students and that card set 3 of the problem solving test was equally difficult for both field independent and field dependent students. These results led the researchers to conclude that students who process information by way of a field independent perspective have a marginal advantage in Logo programming. In addition, Easton and Watson found that the only significant grade effect was for card set 1 of the problem solving test, which showed that second graders used significantly more keystrokes than did the fifth graders. Overall, with regards to time and keystrokes, a significant difference was reported for field independent second graders when compared to field dependent second graders, but not when compared to field dependent or field independent fifth graders. Consequently, field independent second graders were found to do as well as field dependent fifth graders. Their study also showed that grade level and quadrants produced significantly more interactions across all card sets for both keystrokes and times, with fifth grade students demonstrating significantly fewer keystrokes and less time, again across all quadrants. It was concluded that fifth graders quadrant performance was consistently significantly superior to the performance of the second graders. In general, Easton and Watson's results demonstrated that developmental level and spatial strategies students use are significant with regard to children's problem-solving abilities.

CHAPTER III

METHODOLOGY

Subjects

Subjects were fifty-one third grade students and fifty-one kindergarten students enrolled in an elementary school in the Berkeley County School District, Goose Creek, South Carolina. A letter was distributed to the parents explaining the study and requesting permission for students to participate. Parents were advised that their child's participation in the study was strictly voluntary and that withdrawal at any time would not result in any penalty.

Independent Variables

The independent variables for this study were between-subject variables; cognitive style preference, the order of training methods presented, and a cognitive development comparison of kindergartners versus third graders. The cognitive style variable was composed of two types: field dependence and field independence. The order of training variable consisted of two levels: analytical/relational and relational/analytical.

Dependent Variables

The dependent variables in this study were the Logo Problem Solving Test which was subdivided into two parts:

(a) the analytical portion which was operationally defined by Allen (1992) as "the mean of an error term which was in actuality the percentage of grids over the shortest possible path" and (b) the relational portion which was operationally defined as "the mean number of successfully completed paths" (p. 18).

Materials and Equipment

Preschool Embedded Figures Test (PEFT). The PEFT is a modified version of the Children's Embedded Figures Test (CEFT) designed to measure the extent to which a three-to five-year-old child is either field dependent or field independent (Coates, 1972). This test included 24 items which were pictures, each having an equilateral triangle embedded within a figure. The subject was shown the series of pictures and had to accurately locate or disembed the complex figure within 30 seconds. The subject received a score of 1 for each item correctly located. A score of 0 was given otherwise. Thus, a total score equaled the sum of the points. Scores on the PEFT ranged from 0 - 24, with higher scores representing the cognitive style field independence.

The PEFT was found to be a reliable instrument with an internal consistency reliability coefficient that ranged from .74 to .91 and a test-retest correlation of .69 to .75. Validity coefficients range from .08 to .31 for females and from .32 to .49 for males, which suggests that cognitive abilities may not be as discrete for boys at this age as they are for girls (Coates, 1972).

A median-split procedure was used to place students in either the field independent (FI) group or the field dependent (FD) group. The PEFT scores for this group of kindergartners ranged from 8 - 24. Students who scored 17 or above were placed into the field independent group and students who scored 16 or below were placed into the field dependent group. This sample resulted in a split of twenty-three field independent and twenty-eight field dependent subjects.

Children's Embedded Figures Test (CEFT). The CEFT is a modified version of the Embedded Figures Test (EFT) designed to measure the extent to which a five-to-twelve-year-old child is either field dependent or field independent (Karp & Konstadt, 1966). This test includes two different forms each in a series totaling 25 complex pictures, eleven of which have an equilateral triangle embedded within a figure and fourteen which have a house embedded within a figure. The subject was shown a series of pictures and must accurately locate or disembed the complex figure. The subject receives a score of 1 for each item stamped correctly. A score of 0 is given otherwise. Thus, a total score equals the sum of the points. The CEFT scores range from 0 - 25, with higher scores representing the cognitive style field independence.

The CEFT was found to be a reliable instrument with an internal consistency reliability coefficient that ranged from .83 to .90 and a test-retest correlation of .87 at the 5 to 6 age level. Validity coefficients range from .70 to .73 for the 9 to 10 age level and from .83 to .86 for the 11 to 12 age level. Though the validity coefficients are high at the 9 through 12 age levels, they do not establish the validity of the test at younger ages.

A median-split procedure was used to place students in either the field independent (FI) group or the field dependent (FD) group. The CEFT scores for this group of third-graders ranged from 10 - 25. Students who scored 18 or above were placed into the field independent group and students who scored 17 or below were placed into the field dependent group. This sample resulted in a split of twenty-six field independent and twenty-five field dependent subjects.

Computer Equipment. The equipment used in this study was 6 Apple IIe microcomputers with color monitors which the school district provided for each classroom. An additional disk drive was provided for each computer by the researcher. Terrapin LOGO, developed by Terrapin Software, Inc. was the software used in association with the Problem Solving Strategies Training and LOGO Problem Solving Test developed by Allen (1991).

Procedure

Kindergarten students were given the PEFT to assess whether they were primarily field dependent or field independent (FDI). The third grade students were given the CEFT to assess their field dependence or field independence. The study was conducted in the students' classrooms. Each classroom had a computer area which was partitioned off from the rest of the learning environment. Training and testing was done with students individually by the researcher and a team of 6 parent volunteers from the school's Parent/Teachers Association. All trainers/observers were trained to operate the microcomputers, to program in Logo, to present the Logo problem set, and to monitor the software data collection program.

Level 1 - Learning to Maneuver in the Logo Microworld Using the Syntonic Command Method

Level 1 training was carried out over a one-week period with each student receiving an individual computer session each day Monday through Thursday for 15 minutes. There was a total of four sessions or one hour of training on maneuvering within the LOGO microworld. The LOGO software was re-programmed to a procedure called the "Syntonic Command" method (Allen, 1991). This method allowed students to position the cursor in eight different directional positions (north, south, east, west, north-east, north-west, southeast, and south-west) with a single key stroke. By selecting the appropriate color-coded directional "turtle key" students could move the turtle in the direction necessary to solve the problem. The computer was also programmed to provide either big steps (three grid spaces) or little steps (one grid space) known as forward moves, accomplished by using a color-coded single keystroke. Only ten keys (eight turtle keys for directional heading and two forward move keys) were required for students to solve any on-screen problem. Color-coded "turtle key" stickers that corresponded to the keyboard stickers were also attached to the edges of each computer screen. This programming scheme was used successfully by Allen (1992) and was believed to be the most appropriate for the kindergartners (see Appendix A for Color-Coded Directional Keys).

Student were tested on their mastery of the ten maneuvering keys using a 16-item instrument designed by Allen (1991) at the completion of Level 1 training. Students were shown a drawing on a 5 X 8 card and told to "make the turtle do this," thus asking each student to duplicate the drawing by using any of the ten maneuvering keys. Throughout the sixteen cards the degree of difficulty varied. Students were allowed to proceed to the next level after demonstrating an acceptable level of mastery which was successfully completing eight cards.

Level 2 - Problem Solving Strategies Training

During Level 2 problem solving training half of the subjects in each learning style group were randomly assigned to receive analytic training followed by relational training, while the other half of the students received training in the reverse order of presentation. The analytic training required the student to determine the one correct route that would move the cursor from its starting point to its destination in the shortest possible path. The relational training required the student to determine as many different paths as possible to the destination within a two-minute time period.

Logo Problem Solving Test

At the conclusion of the first training sessions, a 16-item LOGO Problem Solving Test (LPST) developed by Allen (1991) was administered. The test included eight analytic problems and eight relational problems presented in random order. As each test item appeared graphics materialized on the computer screen. A short story was read to the students about some situation in which Mr. Turtle found himself. Depending upon which problem type (analytical or relational) was being presented, the story read to the students instructed them to find the shortest possible path or to find as many different solution paths as they could until they were told to stop, which was a two-minute time period. In the analytic problems, once the problem was solved the graphic microworld disappeared and the next story screen was revealed. In relational problems, once a path was successfully found, Mr. Turtle immediately reappeared at the starting point and a different path was found by the student. Each path was displayed in a different color and remained on the screen until the two-minute time limit ran out. This feature in the relational program allowed students to view previously charted paths and therefore, to make decisions as to how each successive path could be achieved to fulfill the request of "as many different paths as possible." At the end of the second training session another LPST test was administered with the same goals of "shortest possible path and charting as many different paths as possible" but using different Mr. Turtle stories (see Appendix B and C for LOGO Problem Solving Tests graphics and stories).

Design

The independent variables in this study were: stylistic differences (Field Independence vs. Field Dependence), developmental levels (Kindergarten vs. Third Grade), and method of training (Analytic/Relational vs. Relational/ Analytic). The dependent measure was scores on the Logo Problem Solving Test. The analytic data which is operationally defined by Allen (1992) as "the percentage of grids over the shortest possible path solution" (p. 23) was analyzed using several 2 X 2 factorial analyses of variance (ANOVA's). Next, similar 2 X 2 factorial analyses of variance (ANOVA's) were performed on the relational data which was operationally defined as "the mean number of completed paths charted to assess each student's relational performance on the test" (Allen, 1992, p. 23). Statistical analyses were done separately on each portion of both LOGO Problem Solving Tests sets since the dependent variable data (analytic and relational problems) were not be comparable.

CHAPTER IV

RESULTS

This sample of elementary school students programmed in Logo about as well as any other group of elementary school students who have been reported in the literature (Clements, 1986; Fay & Mayer, 1987; Easton & Watson, 1992). Without indepth training these students demonstrated Logo cursor maneuverability. Each student completed all 16 analytic problems and 14 relational problems in the Logo Problem Solving Tests A and B. Within the relational portion of the LPST there originally were 16 problems. However, the computer would not allow the students to complete the solution for 2 of the problems, which were identical in graphics but different in story. Therefore, these two problems were deleted from the LPST score for each student. Otherwise, students charted a minimum of two and a maximum of 4 paths in the two minutes allowed for the relational problems.

Data Analysis

Hypothesis 1. It was hypothesized that field independent students would do significantly better than field dependent students on the analytic portion of the Logo problem solving test regardless of order of training.

A 2 X 2 factorial analysis of variance was used to test for significant differences between cognitive style preference (field independence - field dependence) and order of training (analytical/relational or relational/analytical) on the analytic portion of the Logo problem solving test. The unweighted means analysis (Type III) showed no interaction effects or main effect for cognitive style preferences [$F(1,101)=0.59$, $p=.4430$] nor for order of training [$F(1,101)=0.43$, $p=.5111$]. The hypothesis was rejected (see Table 1).

Table 1

2(Stylistic Preference) X 2(Order of Training) Analysis of Variance for the Analytic Portion of the Logo Problem Solving Test with ERROR as the Dependent Measure

Source	df	SS	MS	F	p
FI/FD	1	19657.94	19657.94	0.59	0.4430
Training	1	14409.85	14409.85	0.43	0.5111
FI/FD * Training	1	1646.61	1646.61	0.05	0.8240

Note: The table represents the unweighted means analysis (Type III).

<u>Hypothesis 2</u>. It was hypothesized that field dependent students would do significantly better than field independent students on the relational portion of the Logo problem solving test regardless of order of training.

A 2 X 2 factorial analysis of variance was used to test for significant differences between cognitive style preference (field independence - field dependence) and order of training (analytical/relational or relational/analytical) on the relational portion of the Logo problem solving test. The unweighted means analysis (Type III) showed no interaction effects or main effect for cognitive style preference [$F(1,101)=0.44$, $p=.5100$] nor for order of training [$F(1,101)=0.04$, $p=.8336$]. The hypothesis was rejected (see Table 2).

Table 2

<u>2(Stylistic Preference) X 2(Order of Training) Analysis of Variance for the Relational Portion of the Logo Problem Solving Test with TOTPATH as the Dependent Measure</u>

Source	df	SS	MS	F	p
FI/FD	1	0.3501	0.3501	0.44	0.5100
Training	1	0.0355	0.0355	0.04	0.8336
FI/FD * Training	1	0.0004	0.0004	0.00	0.9819

Note: The table represents the unweighted means analysis (Type III).

Hypothesis 3. It was hypothesized that third grade students would do significantly better than kindergarten students overall regardless of order of training.

A 2 X 2 factorial analysis of variance was used to test for significant differences between developmental level (kindergartners - third graders) defined as grade, and order of training (analytical/relational or relational/analytical) on both the analytical and relational portions of the Logo problem solving test. The unweighted means analysis (Type III) for the analytical portion of the Logo problem solving test showed no interaction effects for order of training [$F(1,92)=0.34$, $p=.5633$] or main effect for order of training [$F(1,92)=0.21$, $p=.6491$]. However, there was a main effect for developmental level [$F(1,92)=59.23$, $p=.0001$].

A t-test was used to determine which developmental level mean was significantly better. The test showed that the kindergartners did significantly better than the third graders on the analytical portion of the Logo problem solving test [$t(45,46)=7.75$, $p=.0001$].

The unweighted means analysis (Type III) for the relational portion of the Logo problem solving test showed no interaction effects or main effect for cognitive development [$F(1,101)=1.85$, $p=.1766$] nor for order of training [$F(1,101)=0.04$, $p=.8471$]. The hypothesis was rejected (see tables 3, 4, and 5).

Table 3

2(Cognitive Development) X 2(Order of Training) Analysis of Variance for the Analytic Portion of the Logo Problem Solving Test with ERROR as the Dependent Measure

Source	df	SS	MS	F	p
Grade	1	7399.77	7399.77	59.23	0.0001
Training	1	26.04	26.04	0.21	0.6491
Grade * Training	1	42.04	42.04	0.34	0.5633

Note: The table represents the unweighted means analysis (Type III).

Table 4

Means, Standard Deviations, and t-Test on Cognitive Development for the Analytic Portion of the Logo Problem Solving Test with ERROR as the Dependent Measure

Grade	M	SD	t	p
Kindergarten	49.13	11.89		
			7.75	0.0001
Third Grade	31.26	10.24		

Note: df=50, $p>.05$

Table 5

2(Cognitive Development) X 2(Order of Training) Analysis of Variance for the Relational Portion of the Logo Problem Solving Test with TOTPATH as the Dependent Measure

Source	df	SS	MS	F	p
Grade	1	2.19256977	2.19256977	2.80	0.0972
Training	1	0.02924157	0.02924157	0.04	0.8471
Grade * Training	1	0.00005640	0.00005640	0.00	0.9932

Note: The table represents the unweighted means analysis (Type III).

Hypothesis 4. It was hypothesized that third grade field independent students would do significantly better than any other group of students on both the analytical and relational portions of the Logo problem solving test regardless of order of training.

In order to directly investigate this hypothesis the students were grouped by cognitive style preference and developmental level, thus creating the variable cognitive style preference/developmental level defined as group. A 2 X 2 factorial analysis of variance was used to test for significant differences between cognitive style preference (field independence - field dependence)/developmental level (kindergarten vs. third grade), and order of training (analytical/relational or relational/analytical) on both the analytical and relational portions of the Logo problem solving test. The unweighted means analysis (Type III) for the analytical portion of the Logo problem solving test showed no main effect for cognitive style preference/ developmental level [$F(3,101)=1.69$, $p=.1740$]; no main effect for the order of training [$F(1,101)=0.50$, $p=.4825$] nor an interaction effect for cognitive style preference/ developmental level and order of training [$F(3,101)=0.60$, $p=.6156$]. The unweighted means analysis (Type III) for the relational portion of the Logo problem solving test showed no main effect for cognitive style preference/developmental level [$F(3,101)=1.19$, $p=.3189$]; no main effect for the order of training [$F(1,101)=0.01$, $p=.9190$] nor an interaction effect for cognitive style preference/developmental level and order of training [$F(3,101)=0.65$, $p=.5873$]. The hypothesis was rejected (see Tables 6 and 7).

Hypothesis 5. It was hypothesized that kindergarten field independent students would score as well as third grade field dependent students on the analytic portion of the Logo problem solving test regardless of order of training.

In order to directly investigate this hypothesis the students were grouped by cognitive style preference and developmental level thus creating the variable cognitive style preference/developmental level defined as group. A 2 X 2 factorial analysis of variance was used to test for

Table 6

2(Grouped By Cognitive Development and Stylistic Preference) X 2(Order of Training) Analysis of Variance for the Analytic Portion of the Logo Problem Solving Test with ERROR as the Dependent Measure

Source	df	SS	MS	F	p
Group	3	164047.61	2164047.61	1.69	0.1740
Training	1	16061.52	16061.52	0.50	0.4825
Group * Training	3	58307.06	58307.06	0.60	0.6156

Note: The table represents the unweighted means analysis (Type III).

Table 7

2(Grouped By Cognitive Developmental and Stylistic Preference) X 2(Order of Training) Analysis of Variance for the Relational Portion of the Logo Problem Solving Test with TOTPATH as the Dependent Measure

Source	df	SS	MS	F	p
Group	3	2.82629866	2.82629866	1.19	0.318
Training	1	0.00825482	0.00825482	0.01	0.9190
Group * Training	3	1.53844141	1.53844141	0.65	0.5873

Note: The table represents the unweighted means analysis (Type III).

significant differences between cognitive style preference (field independence - field dependence)/developmental level (kindergarten vs. third grade), and order of training (analytical/relational or relational/analytical) on the analytical portion of the Logo problem solving test for the two groups of students in question: field independent kindergartners and field dependent third graders.

The unweighted means analysis (Type III) for the analytical portion of the Logo problem solving test showed no main effect for cognitive style preference/developmental level and order of training [$F(1,49)=0.64$, $p=.4295$] nor for the order of training [$F(1,49)=0.41$, $p=.5275$]. However, the unweighted means analysis (Type III) for the analytical portion of the Logo problem solving test showed an effect for interaction of cognitive style preference/developmental level [$F(1,49)=53.30$, $p=.0001$]. A t-test was used to determine which developmental level mean was significantly better. The test showed that the field independent kindergartners did significantly better than the field dependent third graders on the analytic portion of the Logo problem solving test regardless of order of training. The hypothesis was accepted (see Tables 8, 9, and 10).

Hypothesis 6. It was hypothesized that students who are first trained on methods matching their stylistic preferences (field independents on the analytic/relational method and

Table 8

2(Grouped By Cognitive Development and Stylistic Preference) X 2(Order of Training) Analysis of Variance for the Analytic Portion of the Logo Problem Solving Test with ERROR as the Dependent Measure

Source	df	SS	MS	F	p
Group	1	7701.23	7701.23	53.30	0.0001
Training	1	58.56	58.56	0.41	0.5275
Group * Training	1	91.80	91.80	0.64	0.4295

Note: The table represents the unweighted means analysis (Type III).

Table 9

Means and Standard Deviations for Groups and Order of Training

Group	Order of Training	n	Mean	SD
FD 3rd Graders	analytic/relational	12	25.29	9.50
FD 3rd Graders	relational/analytic	11	30.19	10.34
FI Kindergartners	analytic/relational	12	53.00	13.81
FI Kindergartners	relational/analytic	15	52.45	13.33

Table 10

Means, Standard Deviations, and t-Test on Stylistic Preference and Cognitive Development for the Analytic Portion of the Logo Problem Solving Test with ERROR as the Dependent Measure

Group	df	SS	MS	F	p
FI	Kindergarten	44.06	7.25	3.67	0.0007
FD	Third Grade	34.73	9.39		

Note: df=50, $p > .05$

field dependents on the relational/analytic method) would do significantly better than would students trained on nonmatching stylistic preferences.

A 2 X 2 factorial analysis of variance was used to test for significant differences between cognitive style preference (field independence - field dependence) and order of training (analytical/relational or relational/analytical) on both the analytical and relational portions of the Logo problem solving test. The unweighted means analysis (Type III) for the analytical portion of the Logo problem solving test showed no interaction effects for cognitive style preference and order of training [$F(1,47)=2.40$, $p=.1277$]. The unweighted means analysis (Type III) for the relational portion of the Logo problem solving test showed no interaction effects for cognitive style preference and order of training [$F(1,52)=0.36$, $p=.5528$]. The hypothesis was rejected (see Tables 11 and 12).

Table 11

2 x 2 (Grouped By Stylistic Preference and Order of Training) Analysis of Variance for the Analytic Portion of the Logo Problem Solving Test with ERROR as the Dependent Measure

Source	df	SS	MS	F	p
Group	1	842.35	842.35	2.40	0.1277

Note: The table represents the unweighted means analysis (Type III).

Table 12

2 x 2 (Grouped By Stylistic Preference and Order of Training) Analysis of Variance for the Relational Portion of the Logo Problem Solving Test with TOTPATH as the Dependent Measure

Source	df	SS	MS	F	p
Group	1	0.22320755	0.22320755	0.36	0.5528

Note: The table represents the unweighted means analysis (Type III).

CHAPTER V

DISCUSSION

General Findings

The issues of Logo, young children and the microcomputer as a teaching tool in the classroom will continue to be debated well into the next century. However, as previously stated, the cognitive style of the student has seldom been used as a criterion for determining the compatibility or suitability of education through technology. This study was an attempt to address how matching a student's cognitive style with a particular problem solving strategy affected his/her ability to maneuver within a Logo microworld. In addition, the study was designed specifically to investigate kindergartners and third graders with regards to order of training in two different problem solving strategies (analytical and relational). Despite the fact that no significance was found for the hypotheses stated, there is much to be gained by the results presented in this study. There is strong evidence from current research that young children are capable of programming in Logo by using their stylistic preference, being taught successful strategies through age-appropriate theories and demonstrating a preferred strategy in order to problem solve (Allen, 1992; Watson & Busch, 1989; Watson, Lange, & Brinkley, 1992).

Literature has also shown that elementary school students demonstrated that cognitive development, stylistic preference and strategies used were significant when required to test the third through fifth levels of the Watson/Busch Model of Learning Logo (Easton & Watson, 1992). Young children are processing information by learning the syntonic command method (step and directional arrow keys which are color coded) and successfully using it to learn new problem solving strategies (Allen, 1992). This study provides evidence that both kindergarten and third grade students, regardless of stylistic preference and order of training, learned successful problem solving strategies.

Hypotheses 1 and 2

Results showed no significant differences for field independent students performing better on the analytic portion of the Logo problem solving test regardless of order of training, nor for field dependent students performing significantly better on the relational portion of the Logo problem solving test regardless of order of training. Results from both analyses showed no main effects or interactions for stylistic preference or order of training.

With regard to hypothesis 1, the analytic portion of the Logo problem solving test, it was predicted that field independent students would chart more direct path solutions, thus passing through fewer grids. Since it is assumed that field independent students process information without regard for the background and demonstrate greater cognitive restructuring by using internal referents (Goodenough, 1976; Witkin et al., 1967), it was hypothesized that they would maneuver the cursor in the most efficient route (i.e., the shortest path possible) to solve the problems. The fact that both groups performed equally well on the analytic portion of the Logo problem solving test lends support to Allen's (1992) explanation that the design feature of "external environmental cues" having color coded directional keys and their corresponding position attached to the edges of the computer monitor may have assisted the field dependent students in attending to the directional heading that lead them to also problem solve in the shortest possible path. Therefore, the fact that all the students, field independent and field dependent, performed equally well on the analytic portion of the Logo problem solving test may be explained by the use of the age-appropriate Logo training method, syntonic command.

Easton and Watson (1992) found that field independent students did perform significantly better than field dependent students in their study on developmental level, stylistic preferences, and strategy usage. However, the method was different when compared to this study. "External environmental cues" which were available to the students in this study may have resulted in a different outcome for the field dependent students.

In hypothesis 2, the relational portion of the Logo problem solving test, it was predicted that field dependent students would chart more paths per solutions. Field dependent students are thought to be predominantly divergent thinkers characterized as being more capable of simultaneously processing multiple components of a problem (Steffin, 1983). Therefore, it was assumed that field dependent students would perform better than field independent students by charting more paths per solution. However, the results of this study showed that stylistic preference had no effect on actual performance. Therefore, both groups performed equally well on the relational portion of the Logo problem solving test. Again, this lends support to Allen's (1992) explanation that after being trained, thus exposed to relational problem solving strategies in the first Logo problem solving test, that students would exhibit the ability to chart more paths per solution by the time the second Logo problem solving test was administered. Also, these findings are in agreement with Allen's view that having the turtle cursor re-appear at the starting point and charting a new path in a different color allowed students to make decisions for the next path solutions by viewing previously charted paths. Consequently, these results and the findings of Allen (1992), support Goodenough's (1976) description of field dependent students as poor performers of cognitive restructuring tasks where they use non-self referents (prolonged exposure to the relational problem solving strategies) and rely on other means of assistance (external environmental cues) to process information.

Allen's (1992) final explanation of hypothesis 2 addressed the issue of how the test questions were presented to the students. Her results are contrary to what was found in this study. In the Allen study, the students were told that there was no one correct response and that there could be many solutions to the relational problems. In this study the students were asked to find as many different paths as possible. Allen stated that the students' unfamiliarity with this type of questioning may have disguised possible existing differences, demonstrated by anecdotal reports of students' disinterest in finding alternate paths once the original path was determined. However, the students in this study were found to be increasingly motivated to achieve as many paths as possible before the time ran out. Furthermore, most students would have preferred no time limit. Therefore, instructions used in this study may have forced subjects to be active participants in their own learning (Steffin, 1983).

Hypothesis 3

Results for hypothesis 3 showed no significant differences for third grade students when compared to kindergarten students overall. The analysis for the analytic portion of the Logo problem solving test showed no interaction effects or main effect for order of training.

However, there was a main effect for developmental level. For hypothesis 3, it was predicted that third grade students would demonstrate more direct path solutions than would kindergartners on the analytic portion of the Logo problem solving test. Since third graders developmentally are into Piaget's concrete operational stage, it was assumed that they had acquired sufficiently flexible mental operations for spatial symbolic thinking (Piaget & Inhelder, 1967). However, since kindergartners did significantly better than the third grade students on the analytic portion of the Logo problem solving test one is left with proposition that developmental level was not a factor and that in fact kindergartners were better at analytic problem solving. Piaget and Inhelder (1967) found that the emergence of projective space between the ages of 4 and 7 adds a new characteristic to topological space (the learning of spatial concepts) which is a system for locating objects in relation to each other, thus perspective taking. The only explanation that one can offer is that these kindergartners may have been in the process of developing projective space and that this process of locating objects in relation to each other in space sharpened focus on seeking the shortest path possible. Another possible explanation for these results is that the design feature of "external environmental cues" reinforced kindergartners more so than third graders. By having the color coded directional keys and their corresponding position attached to the edges of the computer monitor, kindergartners may significantly have been assisted in focusing on charting the turtle to the target.

In the second portion of hypothesis 3, the relational portion, it was predicted that third grade students would chart more paths per solution than kindergarten students. Again, relying on the assumption that third graders were in the concrete operational spatial stage (Piaget & Inhelder, 1967), data analyses showed no interaction or main effects for developmental level or for order of training. Therefore, the results of this hypothesis indicated that developmental level had no effect. Overall, kindergartners did as well as (on the relational portion) or significantly better (on the analytic portion) than did the third graders on the Logo problem solving test. These findings support Allen's explanation for method of training and exposure problem solving strategies used.

This study stands in contrast to developmental level differences reported by Easton and Watson (1992). Easton and Watson hypothesized that second grade field independent students would do significantly better than second or fifth grade field dependent students on all Logo problem card sets. Easton and Watson reported that fifth graders used significantly fewer keystrokes and significantly less time to problem solve across all quadrants tested than did kindergartners. Easton and Watson concluded that overall fifth grade students' performance was significantly better than was second grader's performance. However, Easton and Watson's Logo training procedures may be argued to have been less age appropriate for the younger subjects than that used in this study. In addition, the Easton Watson training consisted of four Logo command training sessions, where three new commands were introduced in each session; a command training test, and a three-set problem solving test for a total of eight 15-minute sessions. In contrast, the syntonic command method used in this study consisted of four 15-minute training sessions, then a maneuvering test, then 2 different strategy training sessions (eight 15-minute sessions each), and, finally, after the completion of the first strategy training, a 16-item problem solving test, which took approximately 30 minutes, was administered. The total time in training was five hours with one hour of testing compared to the two hours total in the Easton and Watson study. The method of training used and amount of training time probably accounted for differences found in developmental levels when these two studies were compared.

Hypothesis 4

Hypothesis 4 results showed no significant difference for third grade field independent students performance when compared to any other group of students on both the analytical and relational portions of the Logo problem solving test. Both analyses showed no main effects or interactions for order of training or when the students were grouped by cognitive style preference and developmental level. It was predicted that third grade field independent students would construct more efficient direct path solutions and chart more alternate paths than did any other group of students (third grade field dependent, kindergarten field independent, or kindergarten field dependent). Since field independent students were thought to demonstrate superior cognitive restructuring by using internal referents (Goodenough, 1976) and that third graders were thought to function within the concrete operational spatial level (Piaget & Inhelder, 1967), it was assumed that the field independent third graders, regardless of order of training, would construct the most efficient routes and produce the more numerous, different paths. The fact that all groups (field independent third graders, field dependent third graders, field independent kindergartners, and field dependent kindergartners) performed equally well on both portions of the Logo problem solving test, regardless of order of training, supports Allen's (1992) explanations. First, the "external environmental cues" theory of having color coded directional keys and their corresponding positions attached to the edges of the computer monitor may have assisted all the students in focusing on the directional heading that lead the students to problem solve in the shortest possible path. Second, that having the students view previously charted paths allowing them to make decisions for the next path solution combined with the explanation that being trained and/or exposed to both relational and analytic problem solving strategies in the first Logo problem solving test, consequently would have students exhibiting the abilities to both chart more different path solutions and more efficient path solutions by the time the second Logo problem solving test was administered.

Although the results in this study show no significant differences for students when grouped by developmental level and stylistic preference on either the analytic and relational portions of the Logo problem solving test regardless of order of training, such was not the case for the Easton and Watson (1992) study. They hypothesized that second grade field independent students would do significantly better than either second or fifth grade field dependent students on all card sets. With regard to time and keystrokes, a significant difference was found for second grade field independent students when compared to second grade field dependent students, but not when compared to fifth grade field independent or field dependent students. Easton and Watson (1992) found that the second grade field independent students did as well as the fifth grade field dependent students, and that fifth grade field independent students did significantly better than the second grade field independent students on time and keystrokes. A possible explanation for the contradictory reported herein when compared is that in the Easton and Watson study the more age-appropriate syntonic command method of training was not employed. Thus, Easton and Watson students did not have the benefits of "external environmental cues" and additional strategies train time used herein.

Hypothesis 5

Results reported for hypothesis 5 showed significant differences for field independent kindergarten students when compared to field dependent third grade students on the analytic portion of the Logo problem solving test regardless of order of training. There were no interaction effects for order of training, stylistic preference and developmental level nor a main effect for the order of training. However, there was a significant main effect reported for stylistic preference and developmental level. It was predicted that field independent kindergartners would construct direct path solutions as well as field dependent third graders. One assumed that factors which effect field independent processing would be evidenced in analytic problem solving and could possibly be powerful enough to override development stage advantages. Furthermore, one could assume that field independent kindergartners were more concrete operational spatial thinkers than were third grade field dependents. Such attributes might have assisted the field independent kindergartners in charting equally efficient path solutions as field dependent third graders (Goodenough, 1976; Piaget & Inhelder, 1967). Results did show that the field independent kindergartners (specifically those trained in their matching stylistic preference of analytic strategy first, then in relational strategy) did significantly better than the field dependent third graders. These results were in the direction expected concerning order of training, and the power of field independent processing. Having training in analytic strategies helped field independent kindergartners. In fact, field independent kindergartners who were first trained in their stylistic preference and those who were first trained in their non matching styles both did significantly better than did the field dependent third graders. A possible explanation for these findings was stated above.

Results cited above on field independent kindergartners was in confirmation to that reported by Easton and Watson (1992). When comparing field independent second graders and field dependent fifth graders, Easton and Watson reported that the field independent second graders performed as well as did field dependent fifth graders when recording problem solving keystrokes and time to problem solve.

Hypothesis 6

Hypothesis 6 results showed no overall training significant differences between students who were first trained on methods matching their stylistic preferences (field independents on the analytic/relational method and field dependents on the relational/analytic method) and students who were first trained on nonmatching stylistic preferences (field independents on the relational/analytic method and field dependents on the analytic/relational method) on both the analytic and relational portions of the Logo problem solving test. Neither were there any interaction effects for stylistic preference and order of training for the analytic and relational portions of the Logo problem solving test. It was predicted that students who were first trained using their stylistic preference (analytic/relational or relational/analytic) would perform better than students who were first trained on their nonmatching stylistic preference (relational/analytic or analytic/relational) on both the analytic and relational portions of the Logo problem solving test. Thus field independent students who were trained on analytic/relational problems would show more direct path solutions than would their field independent counterparts who were first trained on relational/analytic sequence on both the analytic and relational portions of the Logo problem solving test. Consequently, field dependent students who were trained on relational/analytic would chart more paths per solutions than their counterparts who were first trained on analytic/relational for both the analytic and relational portions of the Logo problem solving test. Since matching one's learning style (cognitive style preference) with appropriate instructional elements (corresponding problem solving strategies) early on is reported to be more essential if educational programs are to be effective (Saracho, 1984), it was assumed that those first trained using their stylistic preference would perform better than would their counterparts who were first trained on nonmatching stylistic preferences. However, the results of this study indicated that stylistic preferences and order of training had no effect on actual performance. Again, these data support Allen's (1992) study.

CHAPTER VI

CONCLUSION

The purpose of this study was to investigate how matching stylistic preference with a preferred and/or not preferred problem solving strategy affected kindergarten and third grade students ability to maneuver within a Logo microworld. Fifty-one kindergarten and fifty-one third grade students, following pretesting and classification as to stylistic preference, were trained on how to maneuver within a Logo microworld using the syntonic command method employed by Allen (1992).

Students were then tested for their problem solving mastery using only ten computer keys. The students then received training in two different problem solving strategies. Following each training session the students were given a Logo problem solving test which consisted of 16 problems, 8 analytic and 8 relational items each.

Study results showed no significant main effects for stylistic preference. In general, field dependent students performed as well as field independent students on both the analytic and relational portions of the Logo problem solving test. Even when students were grouped by developmental level and stylistic preference, no one group outperformed another on these two tasks (analytic and relational). In addition, order of training was tested, finding no learning strategy effect for stylistic preference in relation to either portion of the Logo problem solving test.

Likewise, study results showed no significant main effects for developmental level. When grouped by stylistic preference kindergartners performed as well as did third graders on both portions of the Logo problem solving test. However, quite unexpectedly, results showed a significant interactive effect for developmental level on the analytic portion, but not for the relational portion, of the Logo problem solving test. Kindergartners appeared to have an advantage over the third graders. One could speculate that training was sufficient to equalize performance between kindergartners and third graders and/or that most of the significant interaction could be found in the strength of field independents analytic processing.

Finally, study results showed no significant main effects for order of training. All the students performed equally well, regardless of the order of training, on both portions of the Logo problem solving test. However, results did show an interaction effect for order of training when students were grouped by developmental level and stylistic preference. It was found that field independent kindergartners who were trained in the analytical problem solving strategy first did significantly better than field dependent third graders. Field independent kindergartners appeared to remain focused on their stylistic preference regardless of order of training or exposure to new learning strategies.

In summary, this study provided evidence that developmental level, stylistic preference, and the order of training had practically no significant effects on a student's performance. This study provides support for the viewpoint that age-appropriate Logo training schemes coupled with problem solving strategies prepared young children for problem solving within a Logo microworld. Research is needed to further test the syntonic command method used in this study. Is this training method typical of other elementary school Logo programs? Additional research is also needed to see if a broader development level gap would produce similar results. Furthermore, one needs to clear up the issue of analytic processing strength, why kindergartners did better on conditions related to analytic problems. Also, additional research should be undertaken to see whether something as straightforward as language comprehension may have affected problem solving performance.

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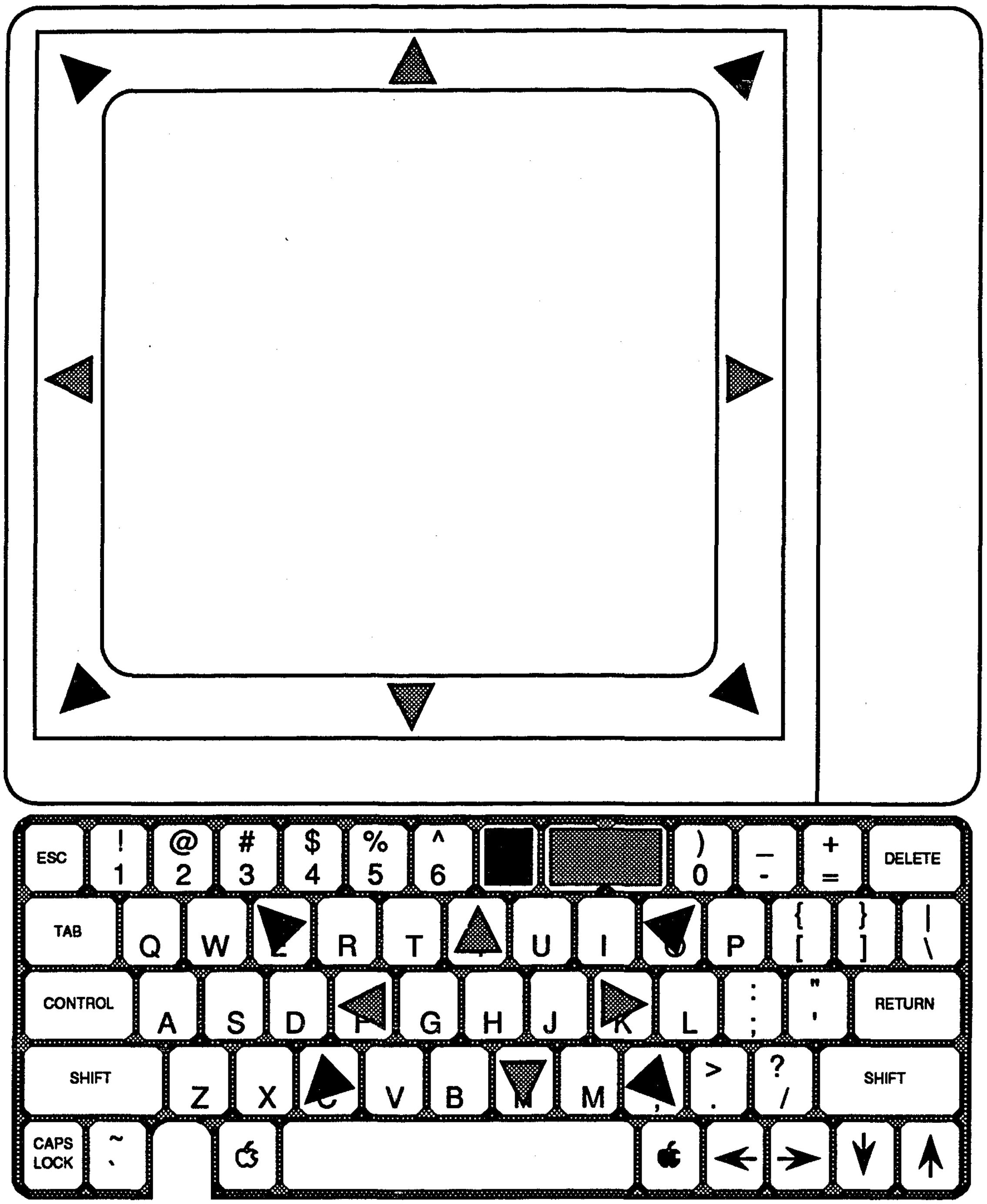
APPENDIX A

COLOR-CODED DIRECTION KEYS



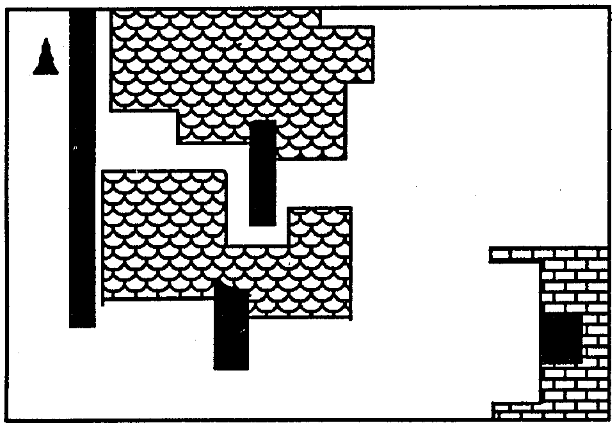
Color-Coding Scheme:

Yellow for big step, north, south, east, and west directional headings

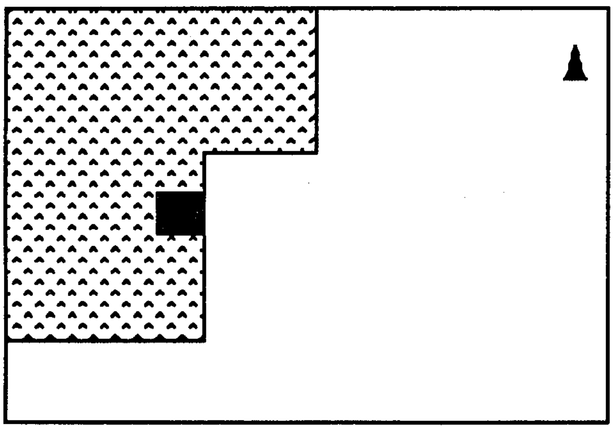
Orange for little step, northeast, northwest, southeast, and southwest directional headings

APPENDIX B

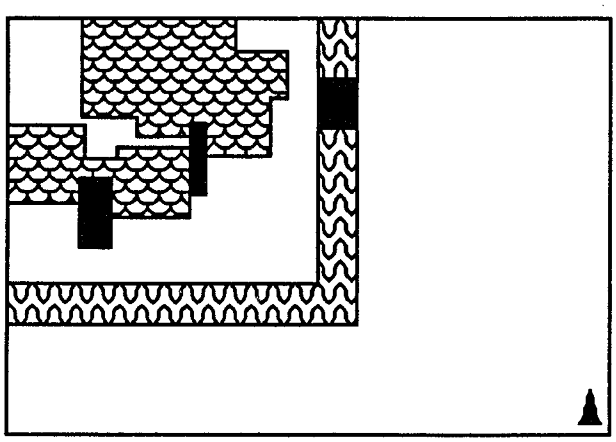
LOGO PROBLEM SOLVING TEST I



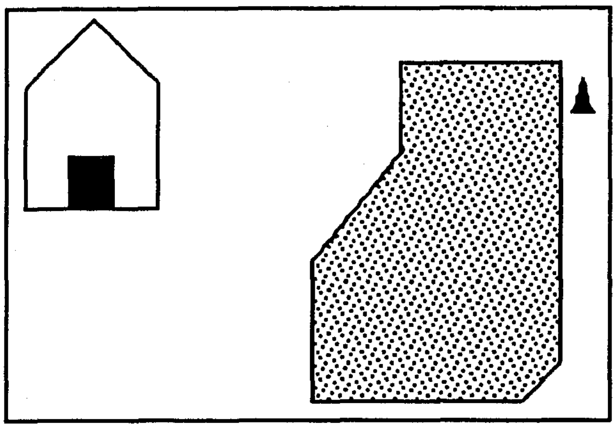
1-A. Mr. Turtle needs to get to school as fast as he can so he can be the first person in line. He cannot climb over the fence or cut through the trees. Help Mr. Turtle get to school so he can be the line leader at school today.



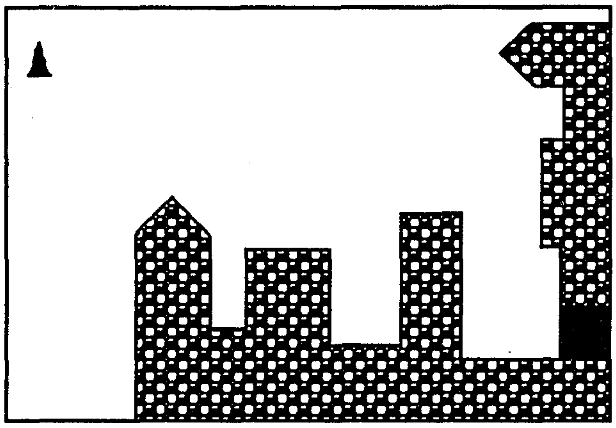
2-R. Mr. Turtle has found a magic box hidden at the edge of the field. Help him get to the box in as many different ways as you possibly can. Once he reaches the box, he will start over again. Each time he finds a new way to get to the box, there is a prize inside for him. See how many prizes you can help Mr. Turtle get.



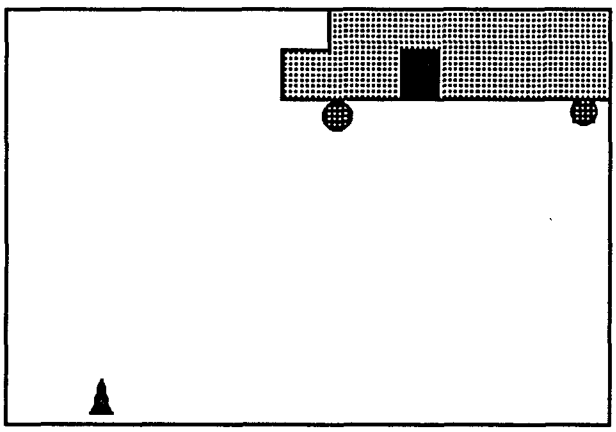
3-R. Mr. Turtle is playing a game. He has to run to the gate that goes into the park. If he finds the most paths that lead to the gate, he will win the blue ribbon. Mr. Turtle needs your help so he can find lots of different ways to get to the gate and be the winner.



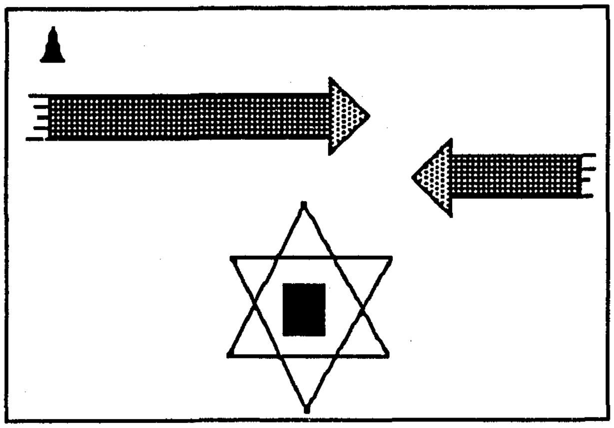
4-A. Mr. Turtle is taking a walk around the lake next to his house and he hears the phone start to ring. Help him run to the house so he he can answer the phone before it stops ringing. He cannot swim across the lake. Help him get to the house as fast as you can because he does not want to miss the phone call from his Grandma.



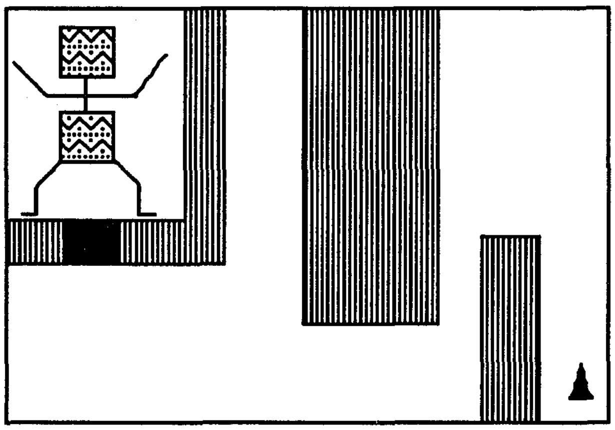
5-R. Mr. Turtle is trying to save all the princesses in the pink castle. He must get to the black door to rescue each one. Once he gets the first princess, he must start all over again. See how many princesses you can help Mr. Turtle save.



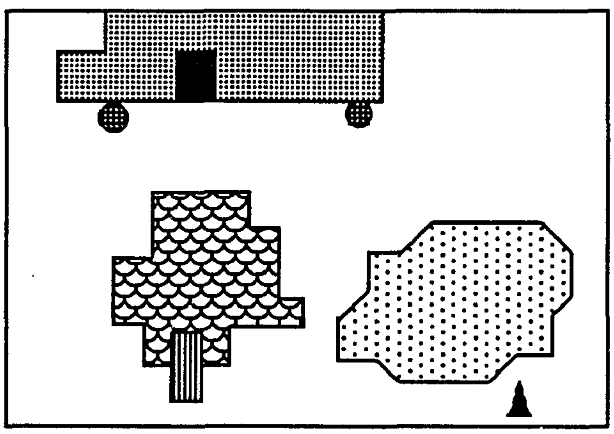
6-A. Mr. Turtle wants to be the first turtle to get on the school bus. If he gets to the bus before anyone else he can sit in the front seat next to the driver. Help Mr. Turtle get to the bus as fast as he can.



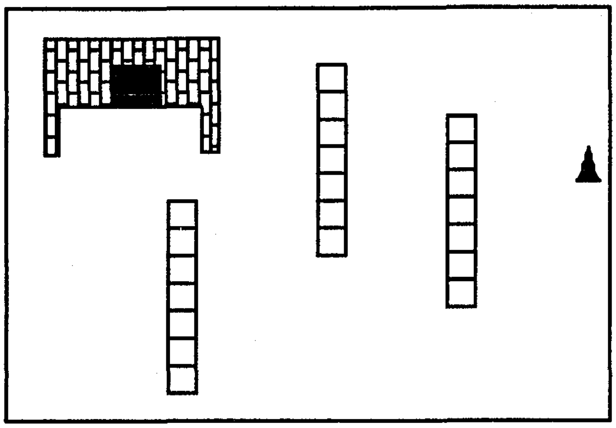
7-A. Mr. Turtle is an astronaut. He is out taking a walk in space. Help him to be the first turtle to stand in the middle of a star. He cannot walk over his rocket ship. Get him to the star the fastest way you can.



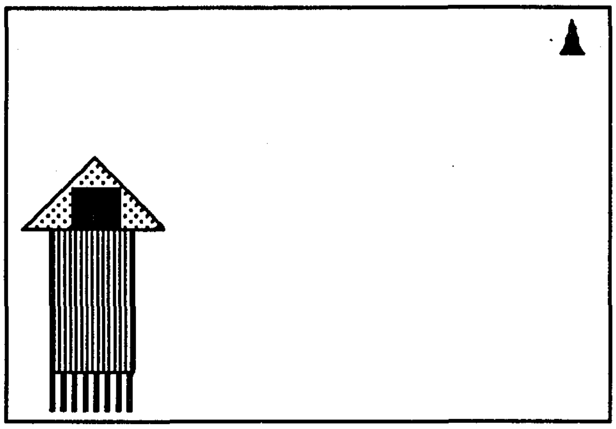
8-A. Mr. Turtle's robot "Harry" has run away. He is hiding in Mr. Turtle's library behind some shelves of books. Help Mr. Turtle find Harry and push the orange button at Harry's feet so he will stay still. Help Mr. Turtle get to Harry before he can run away again!



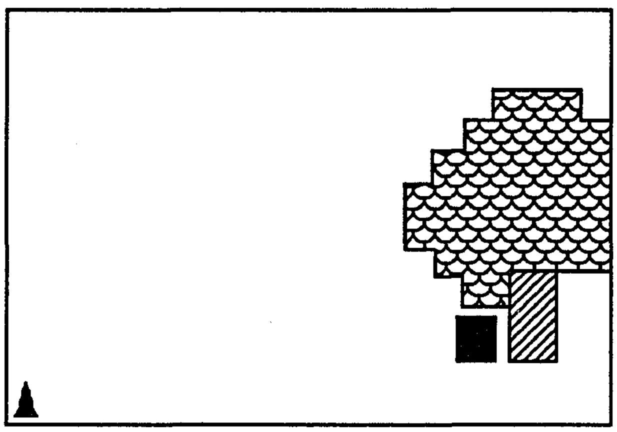
9-R. Mr. Turtle is at the park. He wants to see how many different ways he can find to get back to his school bus. He cannot swim across the lake or go through the trees to get to the bus. Help him figure out as many ways as you can to get back to his bus.



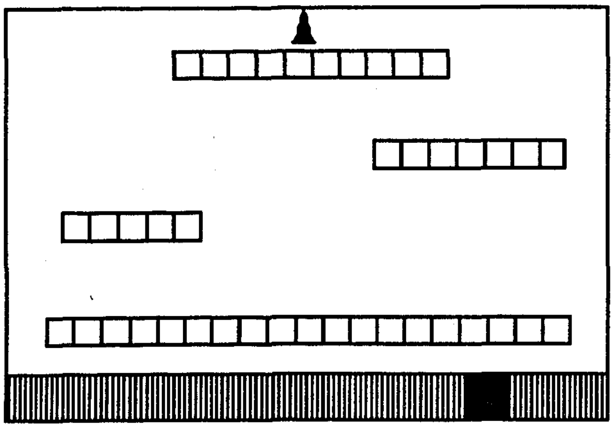
10-R. The Teenage Mutant Ninja Turtles are going to be at Mr. Turtle's school today. Everytime Mr. Turtle finds a new way to get to the front door of his school he gets to meet a different turtle. Mr. Turtle cannot walk through the flower beds in front of the school to get to the front door. Help Mr. Turtle find as many different ways as he can to get to the door so he can meet all the turtles today.



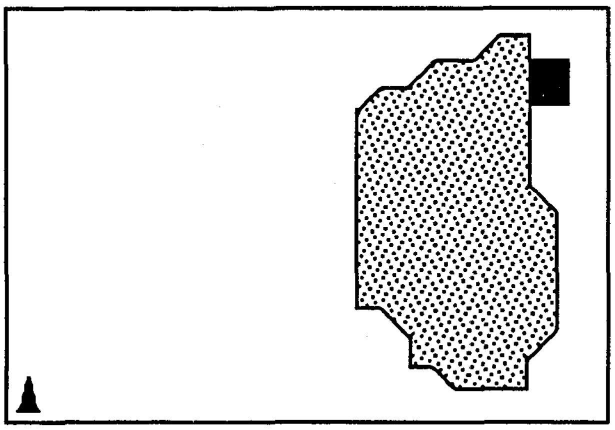
11-A. Mr. Turtle is an astronaut. He has been taking a walk in space and has gotten very hungry. It's time for lunch, and Mr. Turtle must hurry to get back to the spaceship. Help Mr. Turtle get back inside the door of his spaceship as fast as he can so his food will not get cold.



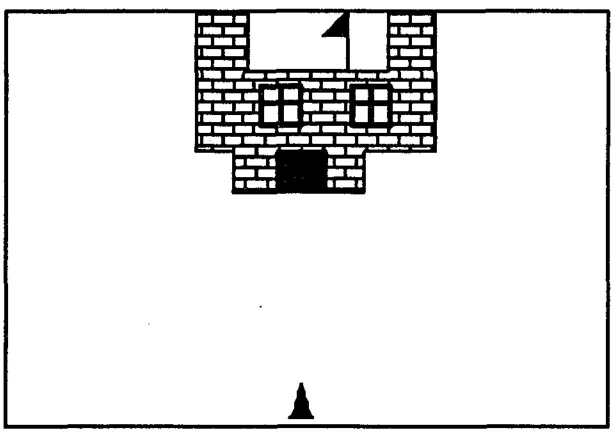
12-A. Today is Mr. Turtle's birthday. His birthday present is underneath the tree. He is very excited to find out what is inside of the box. Help him run to the box as fast as he can so he can find out what his birthday surprise is.



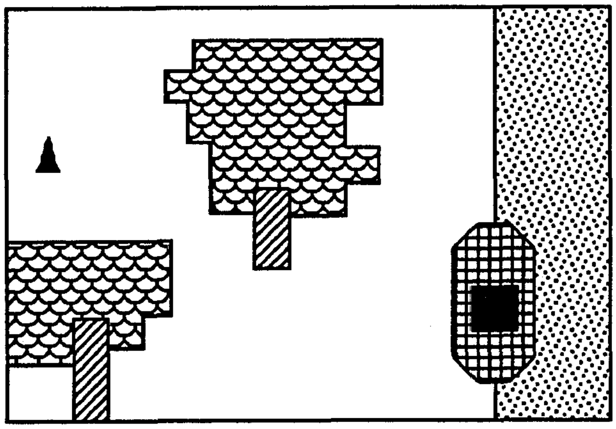
13-R. Mr. Turtle is on a walk to the park. Someone has put up several fences that Mr. Turtle must walk around before he can get to the gate at the park. Help Mr. Turtle find as many different ways as he can to get to the gate. <u>Remember</u>: Mr. Turtle must walk around the fences; he cannot climb over them.



14-R. Mr. Turtle likes to go fishing at the lake. Each time he goes to the fishing pier he likes to take a different path. Mr. Turtle wants you to help him find some new ways to walk to the fishing pier. Help him find as many new ways to walk around the lake to the pier as you can.



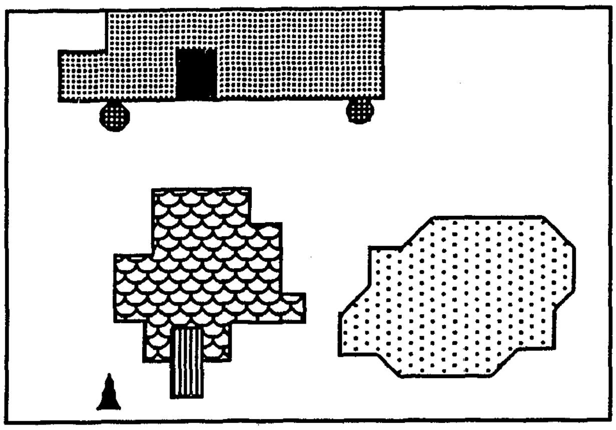
15-A. Mr. Turtle has over-slept and is late for school. Help him get inside the door before his teacher gets angry with him.



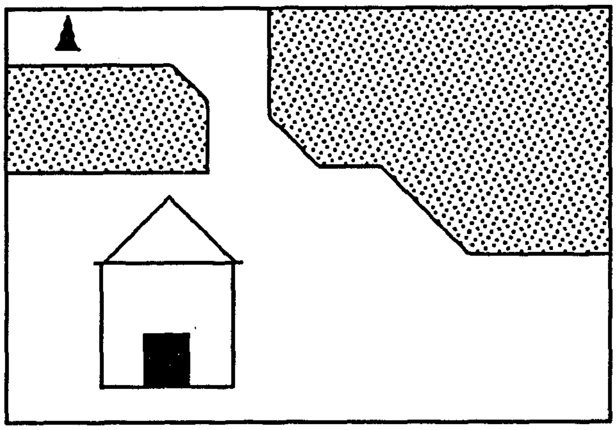
16-R. Mr. Turtle wants to take a ride on the lake in the big boat. Every time he finds a new way to get into the boat he gets another ride. Help Mr. Turtle find as many ways to get to the boat as he can so he can get lots of boat rides.

APPENDIX C

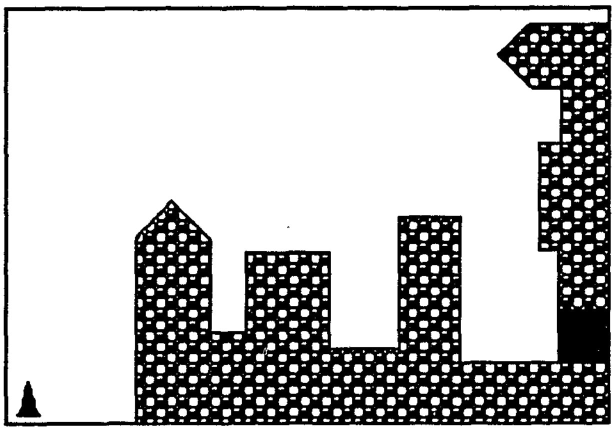
LOGO PROBLEM SOLVING TEST II



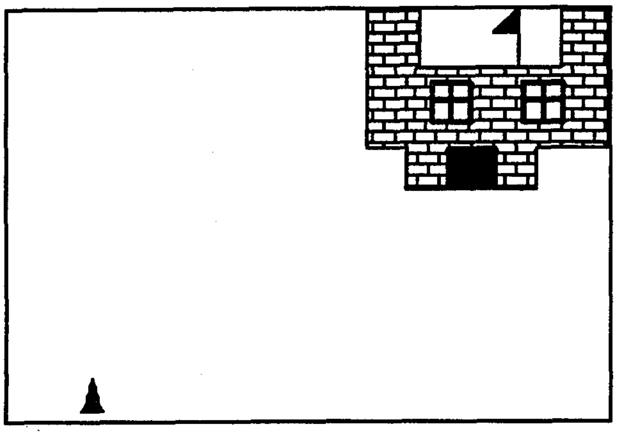
17-A. Mr. Turtle is camping. He needs to find the park ranger's cabin as fast as he can. He cannot swim across the lakes. Help Mr. Turtle see if the park ranger is home.



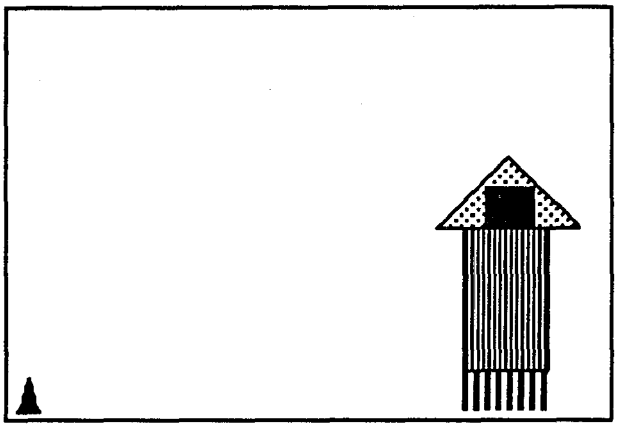
18-R. Mr. Turtle is at the park. He wants to see how many different ways he can find to get back to school bus. He cannot swim across the lake or go through the trees to get to the bus. Help him figure out as many ways as you can to get back to to his bus.



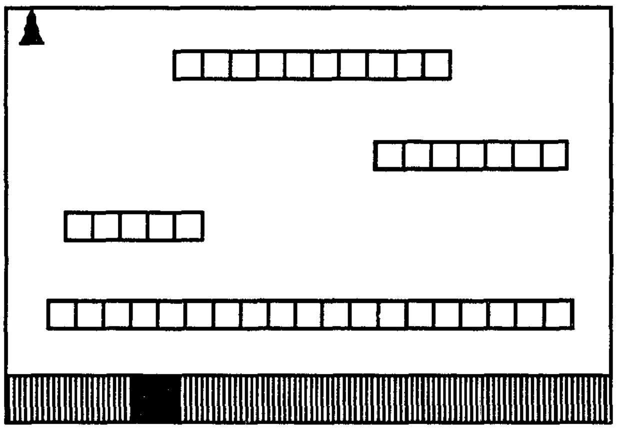
19-R. Mr. Turtle is trying to save all of the princesses in the pink castle. He must get to the black door to rescue each one. Once he gets the first princess, he must start all over again. See how many princesses you can help Mr. Turtle save.



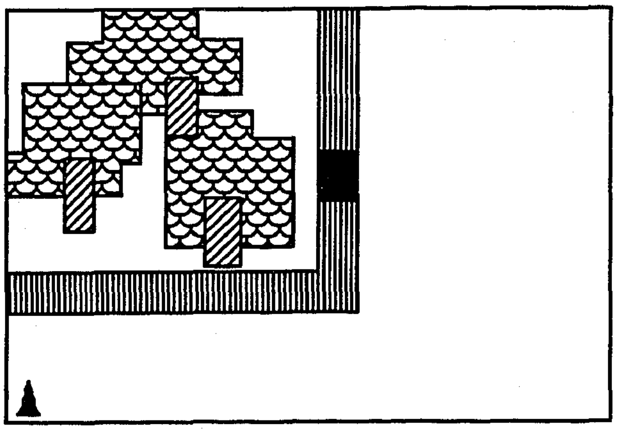
20-A. Mr. Turtle is out on the playground next to his school. It is time to come inside now. Help Mr. Turtle be the first turtle to reach the school door.



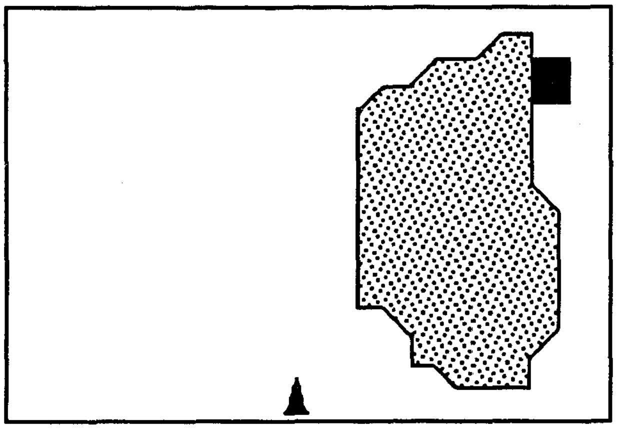
21-A. Mr. Turtle is an astronaut. He is taking a walk on the moon, but he needs to get back to his spaceship right away. Help him find the shortest path back to his spaceship.



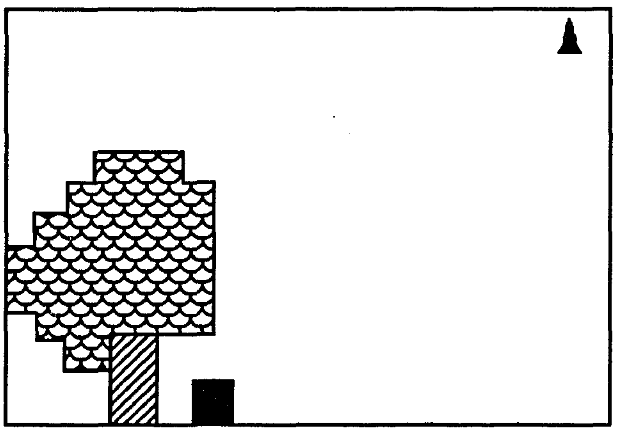
22-R. Mr. Turtle is on a walk to the park. Someone has put up several fences that Mr. Turtle must walk around before he can get to the gate of the park. Help Mr. Turtle find as many different ways as he can to get to the gate. Remember: Mr. Turtle must walk around the fences; he cannot climb over them.



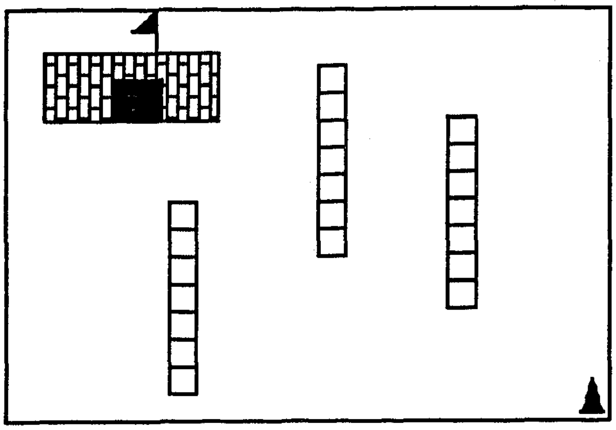
23-R. Mr. Turtle is playing a game. He has to run to the black gate that goes into the park. If he finds the most paths that lead to the gate, he will win a blue ribbon. Mr. Turtle needs your help so he can find lots of different ways to get to the gate and be the winner!



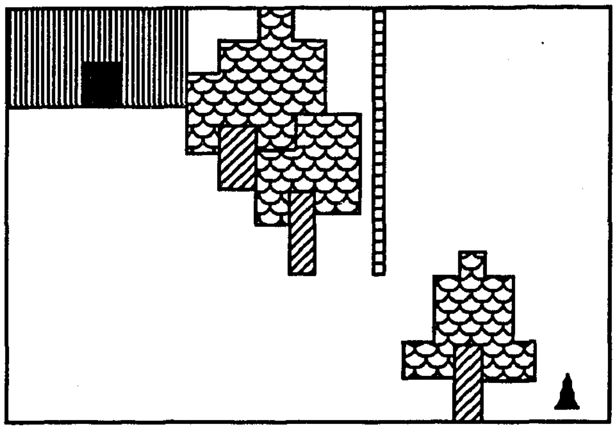
24-R. Mr. Turtle is out for an afternoon swim in the lake. He likes to jump off the pier and then swim to the other side of the lake. See how many different ways you can help him to run to the pier so he can jump into the water.



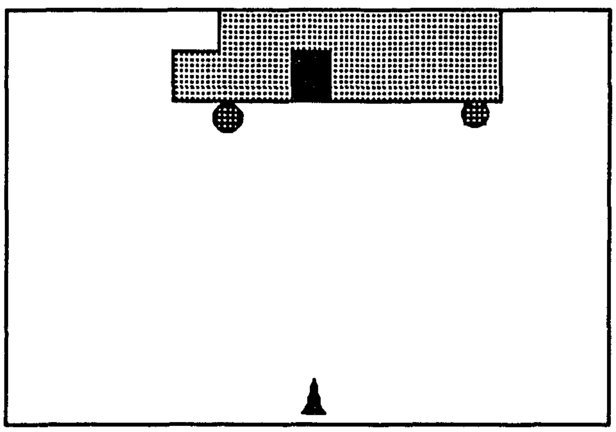
25-A. Mr. Turtle sees that there is a puppy in the box under the tree. Help Mr. Turtle get over to the box to let the puppy out so they can play.



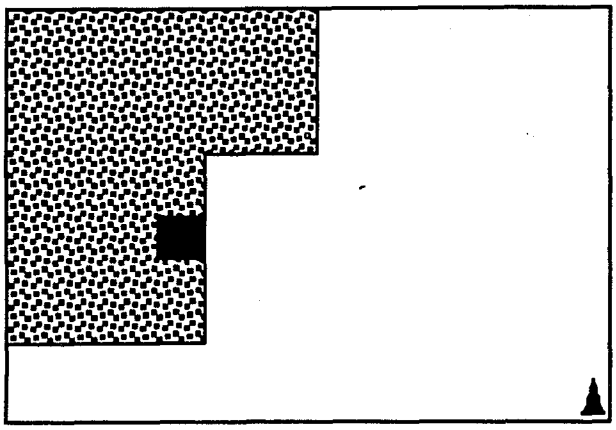
26-R. Mr. Turtle wants to see how many different ways he can get to the door of the school. Each time he wants to go around the flower beds in a different way. See how many times you can help Mr. Turtle get at the school door.



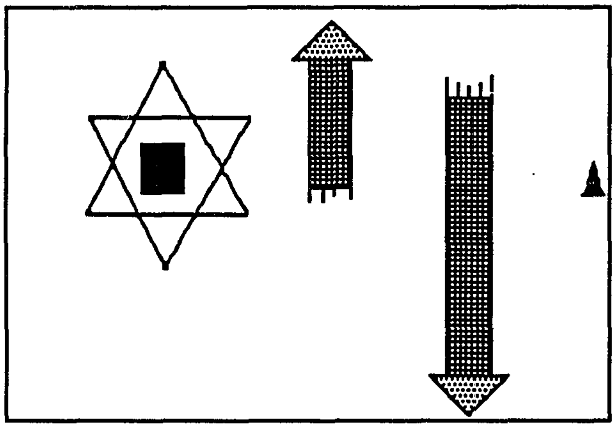
27-A. Mr. Turtle is taking a walk in the park, but it starts to rain. Help Mr. Turtle run to the picnic shelter as fast as he can so he will not get wet.



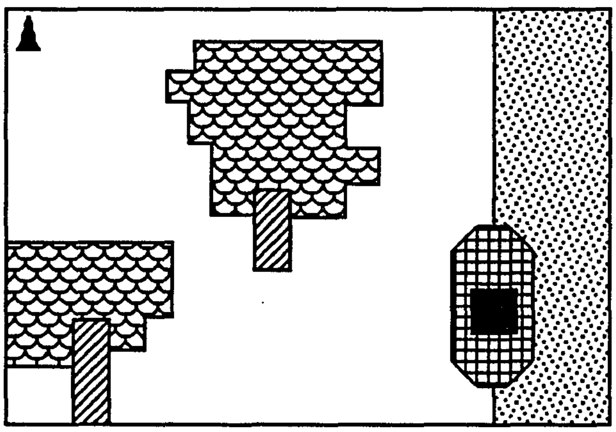
28-A. Mr. Turtle over-slept and he is about to miss the bus. Help Mr. Turtle get out to the bus before the bus driver leaves him behind.



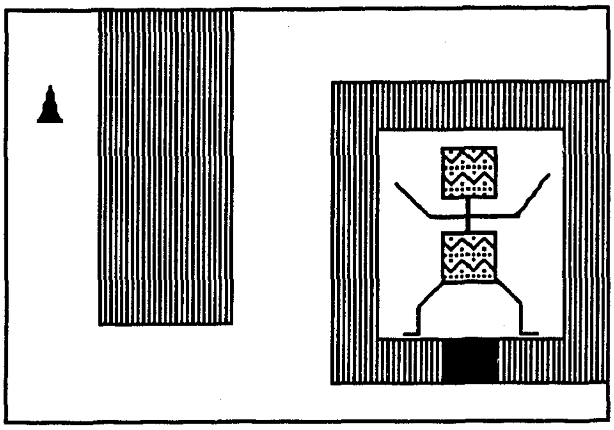
29-R. Mr. Turtle has found a magic black box at the edge of the field. Help him get to the box in as many different ways as he possibly can. Once he reaches the box, he will start over again. Each time he finds a new path to the box there is a prize inside for him. See how many prizes you can help Mr. Turtle get.



30-A. Mr. Turtle is an astronaut. He is out taking a walk in space. Help him to be the first turtle to stand in the middle of the star. He cannot walk over his rocket ship. Help him get to the star the fastest way he can.



31-R. Mr. Turtle wants to take a ride on the lake in the big boat. Every time he finds a new way to get into the boat he gets another ride. Help Mr. Turtle find as many ways to get to the boat as he can so he gets lots of boat rides.



32-A. Harry the robot has run away again and has locked himself in the closet. Help Mr. Turtle find Harry as fast as he can and open the door to the closet so Harry can get out.