

AN ABSTRACT OF THE THESIS OF

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Title: A Comparison of the Metacognitive Behaviors of Field

Independent and Field Dependent Pre-Service Teachers

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Research studies indicated that differences in cognitive processing style influence individual behavior on various types of tasks. This study investigated the effect of the cognitive style dimension, field independence-dependence, on the metacognitive functioning of individuals involved in three problem tasks which varied in inherent structure.

Twenty-six subjects were randomly selected from a pool of one hundred and two pre-service teachers who completed the Group Embedded Figures Test to determine levels of field independence-dependence. Subjects were asked to verbalize their thinking while solving three types of problems. The think aloud protocols were analyzed using a coded analysis technique.

The Checklist of Metacognitive Behavior (CMB) was the classification system developed to perform the coded analysis. The CMB contained four major categories: planning, monitoring, evaluation and affect. Criterion behaviors in each category were identified in the protocols from surface language structure. Behaviors identified in the protocol analysis were assigned points. Analysis of

variance was used to compare mean scores from the CMB for total and category scores on each problem.

Significant differences were found between field independents and field dependents for total and category scores on problem one, the puzzle-type problem. No differences were found between the groups on the semi-structured and ill-structured problems.

Field independents exhibited a greater number and variety of monitoring and evaluation behaviors on the structured problem. Cognitive style preference had no significant impact on the type and number of metacognitive behaviors observed on the semi-structured and ill-structured problems.

A Comparison of the Metacognitive Behaviors of Field  
Independent and Field Dependent Pre-Service Teachers

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# A Comparison of the Metacognitive Behaviors of Field Independent and Field Dependent Pre-Service Teachers

## INTRODUCTION

### Purpose of the Study

The purpose of this study was to assess the degree of field independence-dependence within a group of pre-service teachers and to compare the metacognitive behaviors of the two cognitive style groups.

### Objectives of the Study

1. To determine whether extreme ends of the field independence-dependence continuum existed within a group of pre-service teachers.
2. To determine whether metacognitive behavior during the solution of a structured problem was influenced by the cognitive style dimension, field independence-dependence.
3. To determine whether metacognitive behavior during the solution of a semi-structured problem was influenced by the cognitive style dimension, field independence-dependence.
4. To determine whether metacognitive behavior during the solution of an ill-structured problem was influenced by the cognitive style dimension, field independence-dependence.

### Definition of Terms

Cognitive Style: refers to individual differences in assimilating and accommodating information. Preference for a particular information processing approach develops early and remains consistent and stable



over time (Witkin, et al., 1977).

Field Independence-Dependence: a bi-polar cognitive style dimension.

Field independent individuals can be distinguished from field dependent individuals by the extent to which the individual uses external or internal referents to organize the perceptual field. Field dependents generally work with the perceptual field as it appears without using mediational processes. Field independents tend to analyze the field of perception and to impose structure on the perceptual field when there appears to be no inherent structure (Witkin, et al., 1977).

Metacognition: refers to the knowledge and control that an individual has over thinking and learning activities (Baker and Brown, 1984).

Two components are included within metacognition: knowledge about cognition and self-regulation of cognitive processes (Flavell, 1978).

Knowledge of cognition relates to knowledge of cognitive resources and the compatibility between the learner and the learning situation. Regulation of cognitive processes refers to planning, monitoring and evaluating activities which indicate the progress of the learner in the cognitive endeavor (Flavell, 1985).

Problem: a problem exists when there is a conflict between a situation as it exists and the situation as it should or might be.

Effective resolution of the conflict depends on the amount of information available concerning the gap between the problem state and the goal state (VanGundy, 1981).

Problem Structure: problems may be classified as well-structured, semi-structured or ill-structured depending on the information available to the problem solver (Getzels, 1975); (Simon, 1973).

Well-Structured Problems (WSP): contain all the information required to resolve the problem. Resolution can be accomplished by using defined problem solving procedures (Simon, 1973); (Getzels, 1975).

Semi-Structured Problems (SSP): contain enough information to allow partial definition of the problem state but preclude the exclusive use of defined, routine procedures (Simon, 1973); (Getzels, 1975).

Ill-Structured Problems (ISP): contain minimal information about the best way to achieve problem resolution. The problem solver cannot depend on routine procedures but must generate information required for a solution during the problem solving process (Simon, 1973); (Getzels, 1975). This type of problem requires inventiveness and improvisation (VanGundy, 1981).

Problem Isomorph: a problem whose solution and operations can be put in a one-to-one correspondence with the solution and operations of the original problem (Simon, 1979).

Think Aloud Protocol: a written or spoken verbatim report of an individual's mental processes during cognitive activity (Konold and Well, 1981).

Protocol Analysis: an inductive analysis of the statements made by a subject during a cognitive enterprise (Konold and Well, 1981).

### Relevance of the Study

Rapid social and technological changes have focused the attention of educators, researchers and policymakers on the need to foster development of intellectual skills. Evaluations of student performance have suggested that American students do not possess the cognitive

skills necessary to function effectively in an information-based society (Jones, et al., 1987). American educators have been challenged to design instructional approaches that focus on comprehension and learning to learn skills as the main goals of teaching and learning (Marzano and Arredondo, 1986). In this context, both learning and teaching are perceived as complex thought processes and teacher behavior is viewed as a function of cognitive processing (Parker, 1984).

Research studies have indicated that differences in cognitive processing style influence individual behavior on various types of tasks (Witkin, et al., 1977). Individuals having a field dependent style of processing are globally oriented, extrinsically motivated, impulsive and prefer social situations (Maroufi, 1988). Teachers who are field dependent use instructional approaches that emphasize discussion, factual knowledge and cooperative learning (Witkin, et al., 1977). Field independent teachers prefer inquiry or guided discovery approaches to learning (Witkin, et al., 1977).

Teacher modeling of cognitive and metacognitive processes for students has been determined to be an effective method of fostering the growth of reasoning and monitoring processes (Jones, et al., 1987); (Meichenbaum and Asarnow, 1979). Think aloud procedures in which students are assisted in selecting relevant information in problem solving or evaluating progress while solving problems have been suggested as positive and effective ways for teachers to foster student thinking (Jones, et al., 1987). Field independent individuals are most likely to be adept at this type of teaching and field

dependent students benefit from explicit demonstration of these skills (Witkin, et al., 1977).

Another role of the teacher in cognitive teaching is as the mediator of learning. The mediator intercedes between the learner and the learning environment to help students organize and interpret knowledge (Jones, et al., 1987). Studies have shown that field dependent students at all levels benefit when instructors organize and structure information (Witkin, et al, 1977). Field independent teachers' strengths have been determined to be in their ability to organize and structure learning for students. Both field dependent and independent teachers have been successful in assisting students to interpret information (Witkin, et al., 1977).

The ways in which teachers process information have an impact on instructional approaches and ultimately on student learning. Both field independent and dependent persons can expand their repertoires of behavior if pre-service and in-service programs develop awareness and provide appropriate training in necessary skills (Witkin, et al., 1977).

#### Limitations of the Study

1. The study was conducted with pre-service teachers at a single university.
2. The study sample was randomly selected from students who volunteered to participate in the study.
3. Sixty-five percent of the study sample was female.
4. Secondary pre-service teachers comprised seventy percent of the study sample.

5. Mortality and technical difficulties reduced the original sample of thirty-four (34) participants to twenty-six (26).

## LITERATURE REVIEW

### Cognitive Style: Field Independence-Dependence

The cognitive style, field independence-dependence, was identified in laboratory studies of subjects' ability to recognize the upright position in space. The group of individuals who consistently used the visual field as the primary referent for uprightness was classified as field dependent. Those subjects whose reference point was the body were called field independent (Witkin, et al., 1981). The concept was generalized to indicate the ease or difficulty with which individuals were able to separate a component from an organized field. This perceptual-analytical ability was viewed as a consistent manner of functioning in personal, social and intellectual areas (Witkin, et al., 1981).

Field independence-dependence has received substantial research attention because of the possibility of educational applications. Among the aspects of field independence-dependence that have been studied, cognitive restructuring and autonomy in interpersonal behavior appear to have strong educational implications (Witkin, et al., 1981).

Cognitive structuring skills have been identified as: 1) ability to break up an organized field into basic elements, 2) restructuring of elements into a different organization and 3) structuring of a field that has no inherent organization (Annis, 1979). Cognitive structuring also has been related to an individual's approach to an organized field. Individuals high in cognitive structuring skills

have been determined to take an active approach to problem solving (Annis and Davis, 1978). Field independent individuals have been identified as high in cognitive structuring skills (Annis and Davis, 1978); (Annis, 1979). Investigations of learning processes, such as, hypothesis testing, concept attainment, transfer of learning, and memory have indicated that field independent persons take an active, hypothesis testing approach to learning which has been attributed to their cognitive structuring ability (Witkin, et al., 1981). Field dependents' tendency to accept the organizational field as presented has fostered a more passive, intuitive approach to learning tasks (Witkin, et al., 1977).

Studies dealing with the efficiency and effectiveness of working memory have shown that field dependents and field independents differ in response time and efficiency of rehearsal strategies when the information load in working memory is increased (Robinson and Bennink, 1978). Thirty-two (32) subjects were presented a series of digits followed by a phrase. They were then asked to modify the phrase so that the altered phrase would be similar or opposite in meaning to the original phrase. The modified phrases were presented verbally and then subjects wrote the digits that preceded the phrases. No differences in appropriateness of phrase modifications were found for the three (3) digit spans but significant differences in appropriateness of response were found after the six (6) digit spans. Field dependent errors were the result of using previous rather than current instructions when modifying phrases. Response time for field dependents was also significantly increased. Researchers concluded that the more holistic approach of the field dependent subjects

reduced efficiency when information load in short term memory was increased. In contrast, field independents' active analysis of information allowed a more efficient use of short term memory. It was emphasized that differences in processing strategy rather than storage capacity were the reasons for differences in performance (Robinson and Bennink, 1978).

Frank and Noble (1985) concluded that field independents processed information more efficiently, were less rigid in processing strategies used and made more efficient use of cues. Subjects in this study were asked to solve five (5) non-social and five (5) social anagrams. No significant differences were found in the number of anagrams completed, however, significant differences in favor of field independents were determined in the ease and efficiency in which the anagrams were solved. Field dependents perceived the tasks to be more difficult than field independents. No differences in successful solution were indicated between groups on the social anagrams (Frank and Noble, 1985). Other research has indicated that the socialness factor for field dependents is most critical when the social aspect is incidental rather than inherent in the learning task (Witkin, et al., 1977).

Degree and level of structure vary among academic disciplines. Strategies used within these disciplines also vary in the demands made on the structuring capacity of teachers and students. Differences in strategy preferences have been observed in teachers at both the secondary and elementary levels. Field independent teachers have indicated preferences for discovery or inquiry teaching, whereas field dependent teachers favor class discussion and other techniques



that maximize student-teacher and student-student interaction (Witkin, et al., 1977).

Field independent elementary education majors in science classes performed significantly better than field dependent students on units that were taught using semi-deductive teaching strategies. No differences were found between groups on units in which structured inductive and hypothetico-deductive strategies were used. Classes using the semi-deductive strategy were provided the least amount of structure and individual efforts were emphasized. Students were required to organize their own learning. The structured inductive and the hypothetico-deductive lessons were well-organized, involved group planning, investigation and discussion. Researchers inferred that teaching strategies that incorporate high levels of structure and maximize interaction assist field dependent students and are not disadvantageous to field independent students. Field independent students appeared to be more flexible in ability to learn from strategies that vary in structural level and degree (Shymansky and Yore, 1980).

Studies have suggested a correspondence between content structure and structuring ability (Stasz, Cox and Moore, 1975). Social science has a less defined structure than either science or mathematics. Both students and teachers in a social studies mini-course were asked to organize ten anthropological concepts, e. g. culture and society. Field dependent teachers and students placed the concepts in large, loosely organized groups. Field independent students and teachers formed small, tight groups with minimal overlap. Instruction in organizational patterns did not

alter organization for either group (Stasz, Cox and Moore, 1975).

The cognitive restructuring capacity of field independents has been observed in social and personal as well as intellectual functioning. Research evidence has indicated that field independents are more autonomous, self-directed and self-motivated. In both personal and social domains that lack clarity and organization field independents tend to organize and order situations (Witkin, et al., 1977). In contrast to the impersonal orientation of field independents, field dependents rely more on others to help organize and clarify social situations. They are tuned more to external social cues, seek physical closeness in social situations and are more open in their feelings (Witkin, et al., 1977).

Investigations of learning and memory have provided evidence that differences exist in the way field independents and field dependents process information. These differences have been observed to affect both intellectual and social behavior. Research studies have also indicated that both style preferences can be taught to diversify information processing strategies and social behaviors (Witkin, et al., 1977). Information derived from research on field independence-dependence has provided educators with a basis to make decisions about the appropriateness of teaching and learning strategies for certain style preferences.

### Metacognition

Metacognition has been defined as the knowledge and control that individuals have over thinking and learning activities (Baker and Brown, 1984). Two components were included in the concept, metacognition. The first aspect of metacognition has been identified as knowledge or awareness of "cognitive resources and the compatibility between the learner and the learning situation" (Baker and Brown, 1984). Flavell (1985) has referred to metacognitive knowledge as the "knowledge and beliefs accumulated through experience and stored in long term memory that relate to the human mind and its activities." The metacognitive knowledge stored in memory represents a person's awareness of human beings as cognitive enterprises, awareness of the demands of particular tasks and awareness of strategies required to achieve cognitive goals (Flavell, 1985).

The second component of metacognition was concerned with self-regulatory mechanisms that individuals use to determine progress in cognitive activity (Baker and Brown, 1984). These mechanisms may be conscious or unconscious and include both cognitive and affective experiences relating to cognitive activity (Flavell, 1985). Self-regulation or monitoring of cognitive situations was viewed as an executive process which governs intelligent behavior (Sternberg, 1988).

Awareness and control over cognition has been related to cognitive development (Flavell, 1985). Pre-operational children have more difficulty than older children and adults predicting memory spans,

gauging memory states and rehearsing information for memory storage (Yussen and Bird, 1979). Young children's limited knowledge and experience may affect their ability to understand and interpret cognitive experience (Flavell, 1985).

Current research has focused on both the acquisition of metacognitive awareness and the use of this knowledge to regulate various cognitive tasks. Metacognitive knowledge and control have been determined to be important factors in oral and written communication, attention, memory, reading comprehension, cognitive behavior modification, cognitive style and problem solving. Table 2.1 summarizes the research in these areas.

Table 2.1      Summary of Metacognitive Research

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Attention	Lloyd and Loper, 1986
Cognitive Behavior Modification	Meichenbaum and Asarnow, 1979
Cognitive Development and Memory	Yaniv and Meyer, 1987; Metcalf 1986; Kurtz and Borkowski, 1984; Flavell, 1978
Cognitive Style	Farr and Moon, 1988; Mikulecky and Adams, 1986; Phifer, 1983
Oral Communication	Flavell, 1981
Problem solving	Greenfield, 1987; Quinto and Weener, 1983.
Reading Comprehension	Mikulecky and Adams, 1986; Larson, et al, 1985; Baker and Brown, 1984; Paris, et al, 1984

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Little research has been conducted to examine the role of metacognition in adult problem solving performance. However, studies of

successful and unsuccessful problem solvers have indicated that adults who were effective problem solvers actively planned, monitored and evaluated their cognitive progress (Greenfield, 1987); (Bloom and Broder, 1950). Quinto and Weener (1983) found that high confidence in metacognitive skills and problem solving ability translated into higher task performance for college students. Effective problem solvers exhibited a high degree of self-confidence in problem solving ability and persisted at cognitive tasks until reasonable solutions were reached (Greenfield, 1987); (Bloom and Broder, 1950).

Metacognitive skills related to self-regulation of cognitive activity included: planning moves, monitoring effectiveness of moves, " testing, revising and evaluating " strategies (Baker and Brown, 1984). Schorr's Taxonomy of Comprehension Monitoring Strategies has included planfulness, evaluation and remediation as primary metacognitive skills (Schorr, 1982). Metacognitive skills involved in problem solving have been organized into three major categories: planning, monitoring and evaluation (Beyer, 1988); (Sternberg, 1988); (Presseisen, 1987); (Baker and Brown, 1984); (Schorr, 1982); (Nickerson, 1981). Sternberg has referred to these categories as the metacomponents of intelligence. Planning, monitoring and evaluation were viewed as executive processes which govern problem solving behavior (Sternberg, 1988).

Researchers have also indicated that a strong affective component was involved in metacognitive activity (Greenfield, 1987); (Flavell, 1985). This aspect was related to attitudes that individuals have regarding themselves as problem solvers, task difficulty

and the strategic knowledge required to accomplish the task (Flavell, 1985). Confidence in the solvability of problems and high levels of persistence have been found to relate to successful performance (Greenfield, 1987); (Quinto and Weener, 1983).

The importance of metacognitive skills to effective problem solving has generated interest in the development of programs to foster learning to learn skills. Several of these programs include a metacognitive component. The behaviors identified in the literature that are subsumed by each metacognitive category are outlined in Tables 2.2a, 2.2b, 2.2c and 2.2d.

Table 2.2a Planning Behaviors

Behaviors	Source
goal setting selection of operations sequencing of operations predicting results	Beyer, 1988
developing criteria generating hypotheses clarifying terms defining the problem visualizing ideas	Bloom and Broder, 1950
clarifying data making assumptions about data	Greenfield, 1987
clarifying meanings constructing models verbalizing data focusing attention	Presseisen, 1987
reading instructions determining relevant data	Schorr, 1982
defining the problem using graphic representations allocating resources	Sternberg, 1988

Table 2.2b Monitoring Behaviors

Behaviors	Source
keeping the goal in mind keeping place in sequence spotting errors remedial action	Beyer, 1988
keeping place in sequence checking for errors remediating errors	Bloom and Broder, 1950
keeping goal in mind revising plan	Greenfield, 1987
suspending judgment changing representations keeping place in sequence	Presseisen, 1987
checking errors examining steps	Schorr, 1982
keeping track of steps spotting errors seeking feedback	Sternberg, 1988

Table 2.2c Evaluation Behaviors

Behaviors	Source
assessing goal achievement judging accuracy judging adequacy of solution judging efficiency of the plan	Beyer, 1988
using established criteria judging accuracy judging efficiency	Bloom and Broder, 1950
assessing reasonableness of solution evaluating the solution	Greenfield, 1987
checking accuracy checking efficiency	Sternberg, 1988

Table 2.2d Affect Behaviors

Behaviors	Source
expending effort willing to attend persisting to solution using evidence and reason	Beyer, 1988
using feeling to evaluate confidence in ability confidence in the accuracy of the solution maintaining objectivity maintaining attention persisting to solution	Bloom and Broder, 1950
willing to plan using reasoning processes confidence in ability persisting to solution maintaining attention	Greenfield, 1987
receptive to feedback willing to plan expending effort persisting to solution	Sternberg, 1988

Recent research has indicated a connection between metacognitive awareness and control and cognitive style. This research has focused on the effect of cognitive style on metacognitive behavior in reading comprehension and study skills (Mikulecky and Adams, 1986); (Phifer, 1983). Field independents exhibited greater flexibility in strategy usage (Phifer, 1983). Effective reading and study behaviors have been related to active approaches to reading material and consistent monitoring and evaluation of comprehension (Mikulecky and Adams, 1986).

While studies examining metacognition and problem solving, cognitive style and metacognition and cognitive style and problem solving exist in the literature, investigations of the effects of cognitive



style on metacognitive behavior in a problem solving context are lacking. The focus of this study was to determine the effect of the cognitive style dimension, field independence-dependence, on metacognitive behavior during the solution of problems with variable inherent structure.

## METHODS AND PROCEDURES

The purpose of this study was to determine the effect of the cognitive style dimension, field independence-dependence, on the metacognitive functioning of pre-service teachers.

The following items are described in this chapter:

1. Instrumentation
2. Sampling Procedures
3. Data Collection Procedures
4. Research Design

### Instrumentation

The Group Embedded Figures Test (GEFT) was the instrument used to ascertain the degree of field independence-dependence. This device, developed as a modified form of the Embedded Figures Test, is a group administered test of the ability to break down a structured visual field and to maintain a separation between the part and the whole (Witkin, et al., 1977).

Subjects were required to outline a previously viewed simple design within a complex pattern. The stimulus figures were located on the back of the test to prevent subjects from seeing the simple figure and the complex figure simultaneously.

The GEFT contained three sections. Section one, with seven items, was designed to provide practice for the subjects and was not scored. Sections two and three each contained nine items which grew

progressively more difficult. Subjects were allowed five minutes for each section. One point was given for each embedded figure identified correctly. The scores on the GEFT ranged from zero (0) to eighteen (18). High scores indicated field independence and low scores placed subjects in the field dependent category.

#### Normative Data for the GEFT

Population: college students

Sampling information derived in the standardization process has been outlined in Table 3.1.

Table 3.1 GEFT Norming Sample

Quartile	Men N = 155	Women N = 242
1	0 - 9	0 - 8
2	10 - 12	9 - 11
3	13 - 15	12 - 14
4	16 - 18	15 - 18
Mean	12.0	10.8
Standard Deviation	4.1	4.2

#### Reliability

The Spearman-Brown Formula was used to determine the internal consistency of the GEFT. The  $r$  value was  $+.82$  indicating a high, positive correlation for both male and female groups.

#### Validity

Criterion-related validity was established using the Embedded

Figures Test (parent test) as the criterion measure. The  $r$  value for the male sample was  $-.82$  (high, negative) and  $-.63$  (moderate, negative) for the female sample. Negative correlations resulted from reverse scoring of tests.

### Sampling Procedures

#### Population

One hundred and two undergraduates enrolled in educational psychology and reading methods courses volunteered to participate in this study. (See Appendix A) It was from this population that the study sample was randomly drawn. The composition of this group has been outlined in Table 3.2.

Table 3.2      Composition of the Population

N = 102	Elementary Education		Secondary Education	
	Females	Males	Females	Males
	N = 15	N = 1	N = 53	N = 33

The GEFT was administered to this group to determine the degree of field independence-dependence. Means, quartiles and standard deviations were computed for the group of male subjects and the group of female subjects. Results of this assessment have been summarized in Table 3.3.

Table 3.3 Results of GEFT Testing

Quartiles	Males N = 34	Females N = 68
1	0 - 9	0 - 8
2	10 - 13	9 - 11
3	14 - 16	12 - 15
4	17 - 18	16 - 18
Mean	13.5	12.7
Standard Deviation	3.9	4.3

Standard deviations were used to decide which subjects would be classified field independent and which would be identified as field dependent. Subjects whose scores fell in +1 to +2 standard deviations were determined to be field independent. Therefore, males who scored in the 17 to 18 range on the GEFT were categorized as field independent and females whose scores ranged from 16 to 18 were classed as field independent.

Subjects whose scores fell in -1 to -3 standard deviations were labeled field dependent. Male subjects whose scores were in the 0 to 9 range were identified as field dependent and female subjects in the 0 to 8 range were included in the field dependent category. Specific characteristics of the groups have been represented in Tables 3.4a and 3.4b.

Table 3.4a      Field Independent Data

Elementary		Secondary	
Females	Males	Females	Males
N = 9	N = 0	N = 17	N = 20

Table 3.4b      Field Dependent Data

Elementary		Secondary	
Females	Males	Females	Males
N = 5	N = 1	N = 14	N = 4

The study sample was randomly selected from this group. Based on Cohen's Table, alpha level = .05, beta level = .80 and effect size = .35, the sample size was set at thirty-four. Identification codes were assigned to each subject indicating degree of field independence-dependence, sex and alphabetical position. Every third code in each category was selected until the appropriate sample size had been drawn. The original study sample included seventeen field independents and seventeen field dependent subjects.

Subject mortality and technical problems caused a reduction in

sample size from thirty-four to twenty-six subjects. This sample included fourteen field independents and twelve field dependent subjects.

### Data Collection Procedures

#### Protocol Analysis

Historically behavioral scientists and psychologists have relied on the mental products of individuals to determine the nature of human intellectual processes (Bloom and Broder, 1950). However, mental products have not necessarily provided a reliable or valid image of the cognitive processes used to produce correct solutions to problems. Bloom and Broder (1950), in their study of the problem solving abilities of college students, presented figure analogy problems to six students. Each student achieved the correct solution but examination of verbatim reports of the students' thinking indicated that the thought processes of the six students were quite different. This suggested that a one-to-one correspondence between problem solution (product) and the methods or procedures to reach the solution (cognitive processes) could not be assumed.

Gestalt psychologists have used other methods to describe human thinking processes: introspection and retrospection (Mayer, 1983).

Introspection required the subject to reflect on cognitive processes being used to solve a problem and then report these to the researcher. Questions about the reflections were asked by researchers during interviews with the subjects. A high level of analytical skill was required to accomplish the task successfully. Extensive periods of

training usually preceded experiments (Bloom and Broder, 1950); (Mayer, 1983).

In retrospective protocols, subjects described their cognitive processes after completing the problems. Memory was an important factor in this type of protocol. Subjects often had difficulty remembering exactly how they proceeded step-by-step through the process and provided an edited version implying a logic and order that may not have occurred (Bloom and Broder, 1950); (Mayer, 1983).

Think aloud protocol analysis has provided an alternative to introspective and retrospective protocol analysis as well as a departure from the use of mental products as the sole sources of information about cognitive processes.

Subjects were presented with three types of problems to solve. While they solved each problem, subjects provided a verbal account of their thinking which was tape recorded. The recordings were transcribed and the transcripts were analyzed using the coded analysis technique (Konold and Well, 1981).

Coded analysis required the development of a classification system which would define the key elements related to metacognitive functioning in a problem solving situation. The Checklist of Metacognitive Behaviors (CMB) was designed to assist the researcher to identify key words, phrases or sentences in the protocols that represented those elements. (See Appendix B)

Four major categories were included in the CMB: planning, monitoring, evaluation and affect. Planning, monitoring and evaluation were classified as executive processes which regulate cognitive acti-



vity (Baker and Brown, 1984); (Beyer, 1988); (Sternberg, 1988). The affect category was included to represent attitudes, beliefs and feelings that individuals experience during cognition (Flavell, 1985). These elements often had an affect on ability to participate effectively in cognitive endeavors (Bloom and Broder, 1950); (Flavell, 1985).

The criterion behaviors in each category have been identified in the literature as behaviors essential to successful problem solving performance (Bloom and Broder, 1950); (Newell and Simon, 1972); (VanGundy, 1981); Presseisen, 1987); Beyer, 1988); (Ruggiero, 1988); (Sternberg, 1988).

The focus of the coded analysis was on surface structure. Words, phrases and sentences relating to the criteria in each category were highlighted and labeled by category and criterion. For example, the sentence " I have to write this out so I can understand it better " was labeled P11 (planning- graphic representation).

When a behavior was initially identified as representing a criterion behavior, one point was assigned to the behavior. Points were given only for the initial exhibition of the behavior. Subsequent manifestations were noted but not assigned points. Both total and category scores were calculated for each subject. The highest possible score was thirty-nine (39). Category scores varied since criteria differed in each section. The highest possible scores in each category were: Planning-20, Monitoring-7, Evaluation-4 and Affect-8.

#### Facilitators

Seventeen (17) graduate students enrolled in the advanced

educational psychology course were trained by the researcher to act as facilitators in the problem solving sessions. Training was done in small groups and included the following aspects:

1. explanation of think aloud protocols
2. description of the problem solving tasks
3. modeling the facilitator's role
4. practice of facilitation techniques

The facilitators' task in the problem solving sessions was to present each problem and explain the think aloud procedure to the subjects. The facilitators tape recorded the subjects verbal responses. During the problem solving activity, facilitators did not interact with subjects except to remind them, if necessary, to verbalize their thoughts.

#### Problem Solving Sessions

Each subject participated in three problem solving activities. (See Appendix C) The time required to reach a satisfactory solution depended on the pace set by the subject.

The think aloud procedure was explained to each subject in the initial session and reviewed in subsequent sessions. Subjects were provided with practice problems at each meeting so they would be at ease with the think aloud technique. (See Appendix D) After the subjects indicated readiness to begin, the tape recorder was turned on and the problem task was presented to the subject. Recordings provided the verbatim accounts used by the researcher for analysis.

#### Research Design

Statistical Analysis: One Way Analysis of Variance.

Statistical Tool: F Ratio      Significance Level = .05

The one way analysis of variance was used to determine whether significant differences existed between the two groups.

The F ratio has been determined to be a robust statistical tool for assessing differences between means and not to be seriously affected by possible violations of the theoretical assumptions on which it is based. (Courtney, 1986).

Design Matrix

Cognitive Style	
Field Independents	Field Dependents
N = 14	N = 12

$$H_0: u_a = u_b$$

$H_1$ : There is no significant cognitive style effect for Problem One.

$H_2$ : There is no significant cognitive style effect for Problem Two.

$H_3$ : There is no significant cognitive style effect for Problem Three.

$$\text{Mathematical Model: } Y_{ij} = u + a_i + E_{ij}$$

$u$  is the fixed constant.

$a_i$  is the fixed effect of cognitive style.

$E_{ij}$  is the error term.

Table 3.5      Anova Layout

Source of Variation	Degrees of Freedom	Mean Square	F Ratio	Tabular F
Cognitive Style	1	CS/1	$\frac{MS}{CS/MS_E}$	4.26
Error	24	E/24		
Total	25	CS/1 + E/24		

Sample sizes were unequal in this study. It was essential, therefore, to test for homogeneity of variance to validate the use of the analysis of variance procedure. Hartley's F max test was used to determine whether this assumption was met.

$F_{\max} = \text{maximum group variance} / \text{smallest group variance}$

Degrees of Freedom for variance =  $k - 1$

Critical Tabular Value = 39.0

Problem One Total Scores:  $F_{\max} = 4.7$

Problem Two Total Scores:  $F_{\max} = 1.01$

Problem Three Total Scores:  $F_{\max} = 1.53$

Since the computed  $F_{\max}$  value was less than the tabular  $F_{\max}$  value variances were assumed to be equal.

## RESULTS OF DATA ANALYSIS

The purpose of this study was to determine the effect of the cognitive style, field independence-dependence, on metacognitive behavior in three problem solving situations.

Subjects were presented with three problems varying in inherent structure and asked to describe their thinking as each problem was solved. These think aloud protocols were tape recorded and transcribed. The Checklist of Metacognitive Behavior was used to perform a coded analysis of each protocol. Key words and phrases that pertained to the criteria in the classification system were identified and each observed behavior was assigned one point. A one way analysis of variance was used to compare mean scores on each problem for the two cognitive style groups.

### Problem One

$H_1$ : There is no significant cognitive style effect for Problem One.

Mean scores were compared for total scores and for each separate category within the checklist. The results of the data analysis for the Total CMB Scores have been summarized in Table 4.1.

Table 4.1      Total Score Results for Problem One

Source of Variation	Degrees of Freedom	Mean Squares	F-Ratio	Tab F
Total Score	1	416.00366	8.523	4.26
Error	24	48.80754		
Total	25			

Significant differences were found for Total Scores supporting

rejection of hypothesis number one,  $H_1: u_{FI} > u_{FD}$ .

Results of the data analysis for each category have been outlined in Tables 4.1a, 4.1b, 4.1c and 4.1d.

Table 4.1a Planning Score Results for Problem One

Source of Variation	Degrees of Freedom	Mean Squares	F-Ratio	Tab F
Planning	1	59.546703	4.653	4.26
Error	24	12.796131		
Total	25			

Small but significant differences were found between field independents and dependents for Planning Mean Scores.

Table 4.1b Monitoring Score Results for Problem One

Source of Variation	Degrees of Freedom	Mean Squares	F-Ratio	Tab F
Monitoring	1	28.044872	8.318	4.26
Error	24	3.371528		
Total	25			

Data analysis indicated significant differences between field independents-dependents for Monitoring Mean Scores.

Table 4.1c Evaluation Score Results for Problem One

Source of Variation	Degrees of Freedom	Mean Squares	F-Ratio	Tab F
Evaluation	1	2.7701465	4.635	4.26
Error	24	.5977183		
Total	25			

Analysis of the Evaluation Mean Scores yielded small but significant differences in favor of field independents.

Table 4.1d      Affect Score Results for Problem One

Source of Variation	Degrees of Freedom	Mean Squares	F-Ratio	Tab F
Affect	1	30.33333	7.023	4.26
Error	24	4.31944		
Total	25			

Comparisons of Affect Mean Scores indicated that significant differences in favor of field independents existed between the two cognitive style groups.

Total Score mean comparisons for female independents and male field dependents yielded significant differences between these two groups ( $p < .05$ ). Actual mean differences for female field independents were substantially higher than female dependents but data analysis indicated the the differences were not significant ( $p < .05$ ).

No significant differences were found in any group comparisons for Planning and Evaluation categories. Data analysis of Monitoring mean scores showed that there were significant differences for all field independent subjects compared to male field dependent subjects. Results of the data analysis for Affect means indicated significant differences in favor of field independents between female independents and all field dependent subjects.

Comparisons by content were completed for three areas: language arts, social studies and science. Other content areas could not be grouped for comparisons due to insufficient numbers. The three major contents listed above accounted for twenty (20) of the twenty-six (26) subjects included in the study. The results of the analysis for each content area compared showed no significant differences existed between groups for total scores or category scores.

#### Problem Two

$H_2$ : There is no significant cognitive style effect for Problem Two.

Results of the one way analysis of variance for Problem Two are represented in Table 4.2. Analysis of the data revealed no significant differences between groups for total or category scores. No differences were found for total or category scores on gender or content area comparisons. Therefore, hypothesis number two was retained:  $H_2: u_{FI} = u_{FD}$ .

Table 4.2      Summary of Results for Problem Two

Source	F-Ratio	Tab F
Total Scores	.025	4.26
Planning Scores	.000	
Monitoring Scores	.433	
Evaluation Scores	.100	
Affect Scores	.185	



### Problem Three

$H_3$ : There is no significant cognitive style effect for Problem Three.

No significant differences were found between the cognitive style groups on total or category scores for Problem Three. Gender and content area comparisons also yielded no significant differences between the group means for total or category scores. Data have been summarized in Table 4.3.

Table 4.3      Summary of Results for Problem Three

Source	F-Ratio	Tab F
Total Scores	1.026	4.26
Planning Scores	.495	
Monitoring Scores	.509	
Evaluation Scores	.362	
Affect Scores	.843	

### Discussion of Results

#### Problem One

The Tower of Hanoi problem was attempted by six field independent and four field dependent subjects. The problem required subjects to analyze a task and restructure the elements to achieve a solution. Subjects were not provided a pictorial representation of the problem which necessitated manipulation and interpretation of verbal data to understand the problem.

Five of the six field independents solved the problem correctly while only one of the four field dependents achieved the correct solution. The field dependent subject's solution required fourteen

moves. Of the field independents achieving solution, one took eleven moves, two used nine moves and two required seven moves which is the minimum number of moves necessary to solve the problem.

Examination of protocol statements indicated that the subjects solving the problem correctly exhibited more monitoring and evaluation behaviors than subjects not obtaining a solution. The edited think aloud protocols of one field dependent subject (FDB) and the field independent subject (FIM) who did not solve the Tower of Hanoi problem correctly have been included to illustrate the types of behaviors inferred from the protocol statements.

Subject FDB:

Statements	Metacognitive Behaviors
S1. I can't even visualize this.	lack of confidence difficulty representing information
S2. I have to draw out the 3 posts and the 3 disks.	graphic representation
S3. What kind of disks?	clarifying terms
S4. I can't visualize this.	lack of confidence difficulty representing information
S5. The disks-whatever they are-are arranged in pyramid fashion.	clarifying terms
S6. Now that I have drawn it I can see it.	graphic representation
S7. If I move disks from post to post it won't look the same unless I have two smaller disks.	elements missing
S8. How can I when there won't be as many disks on the left as the right?	more information needed
S9. I can't do it.	lacks confidence
S10. I don't see how it can be done if you take away disks on the left like horseshoes or something.	too difficult
S11. You are always taking something away so it will never look like the left one.	cannot represent information
S12. Am I done with this problem?	frustration, avoidance

Inability to completely understand the task prevented this field dependent subject from constructing an adequate internal representation of the problem elements. The subject decided that the problem was unsolvable and was anxious to terminate the session (S12: "Am I done with this problem?").

Subject FIM:

Statements	Metacognitive Behaviors
S1. I'm drawing 3 posts with 3 disks on the left post in pyramid fashion.	representing information
S2. I need to move the disks to the right.	stating a goal
S3. That's hard because I just want to flip them around to the right.	feeling awareness
S4. I'll place the small on the left and the large in the middle.	trial and error
S5. That's not right. I'm going to start over.	aware that strategy is not working aware of mental state
S6. This is very confusing.	
S7. I've got to put the small disk on the right and the large in the middle and then the small back on the left.	trial and error
S8. I'll put the middle one-no I can't do that.	aware of error
S9. I'll have to start over.	aware strategy is not working
S10. Small disk to the right and middle to the middle and large to the right so it is on the bottom.	
S11. Small disk goes to the left and the middle to the right.	
S12. Then the small goes to the right.	remedial strategy
S13. That should do it.	did not recheck confident in solution

The protocol of the field independent subject indicated use of a trial and error strategy after initial confusion about the task requirements. The subject had difficulty keeping track of legal moves which resulted in an erroneous solution. Sentence 10 violates Rule #2 of the Tower of Hanoi problem which states that a larger

disk may not be placed on a smaller disk. However, Sentence 13 indicates that the subject was confident that the solution was correct.

Field independent subjects exhibited a greater number and variety of metacognitive behaviors while solving the Tower of Hanoi problem. Field dependent subjects had greater difficulty representing problem elements as well as keeping track of legal moves and using criteria to determine the accuracy of their solutions. Regardless of cognitive style, subjects achieving a correct solution engaged in more monitoring and evaluation behaviors than subjects who failed to reach a correct solution.

Sixteen subjects had solved the Tower of Hanoi problem prior to participation in the study. Eight field independents and seven field dependent subjects were asked to solve the Monsters and the Globes problem which is an isomorph of the Tower of Hanoi problem. None of the subjects reached a correct solution to this problem. Both field independents and field dependents had difficulty keeping track of legal moves made toward solution. All subjects were confident in the correctness of their solutions.

Supplementary analyses were performed to determine if differences existed between the field independent and field dependent subjects on the Monsters and the Globes problem. Significant differences were found for the monitoring category only. Despite the differences in this category, an examination of the protocols indicated that both groups had problems keeping track of legal moves.

Three rules governed the legality of the moves made in the Monsters and the Globes problem. Subjects in both cognitive style

groups used either Rules #1 and #2 or Rules #1 and #3 to evaluate the accuracy of their solutions. All subjects failed to use the three criteria to determine whether or not the problem had been solved successfully.

Comparisons of mean scores for field independents solving the Tower of Hanoi problem and the field independents who worked the Monsters and the Globes problem yielded significant differences between the two groups. The Tower of Hanoi group exhibited a greater number of monitoring, evaluation and affect behaviors than the Monsters and the Globes group.

Only one subject attempted the Tea Ceremony problem which was also an isomorph of the Tower of Hanoi problem. This field dependent subject viewed the problem as an explanation of the social customs of a particular culture rather than as a puzzle to be solved. Despite the fact that the subject was familiar with the Tower of Hanoi problem, no connection was made between the task requirements of the two problems. Field dependent persons have been determined to focus on the most salient aspects of situations (Witkin, et al., 1977). This subject focused on cultural information in the problem which was not relevant to the task involved.

The following excerpt from the subject's protocol illustrates the interpretation of the Tea Ceremony problem.

- S1. As I understand it the tasks are accomplished by the most senior member.
- S2. This is done by the most honored member.
- S3. It is something of a seniority system.
- S4. They are honoring the traditions in their society.

All three structured problems were presented in written form without pictorial representations. However, the Tower of Hanoi

problem was more simply stated and included only two evaluation criteria. Both the Monsters and the Globes and the Tea Ceremony problems included complicated verbal explanations and directions. The Tea Ceremony was presented in story form and the three evaluation criteria were embedded in the narrative. Difficulty in translating involved verbal material may have contributed to subjects' failure to obtain correct solutions.

#### Problem Two

Examination of think aloud protocols indicated that field dependents and field independents who received high scores in the coded analysis (32-26) shared several behaviors in common. All subjects initially refused to recognize a problem because the problem was written as a statement rather than as a command or a question. However, after stating this fact several times, subjects decided to pose their own questions and proceeded to outline presentations on the suggested topic. The subjects with the two highest scores (FDV-32 and FIG-31) included both introductory and summary statements. Each developed major categories which were listed in order of importance to the target audience.

Field independents and field dependents who received the lowest scores (1-4) also had similar responses. Samples of statements from protocols of the low scoring group have been listed in Table 4.4.

Table 4.4      Sample Protocol Statements from Subjects with Low  
Scores on Problem Two

Field Independents	Field Dependents
" So there's no problem."	" I don't see anything wrong."
" I can't really see a problem."	" I don't see the problem."
" Is this a trick question?"	" There's no problem."

Subjects were affected by the form of the problem. Some subjects not finding direction in the statement created their own problem statement and then solved for that problem. These subjects, therefore, manifested more of the criterion behaviors included in the Checklist of Metacognitive Behavior.

#### Problem Three

This problem required subjects to perform two related tasks. First, the subjects were asked to formulate an educational problem that they considered significant. Problem finding, like problem solving, involves divergent and convergent processes. Individuals initially explore areas of concern and gradually limit selections to those situations or events for which they might develop workable solutions (VanGundy, 1981). Formulation of the problem is the last step in problem discovery and the first step in the problem solving process (Dillon, 1975). Developing a solution to the posed problem was the second task presented to the subjects.

Cognitive style preference had no significant impact on the type and number of metacognitive behaviors observed on this ill-structured problem. Many subjects, regardless of cognitive style,

remained in the problem finding phase of the task. These subjects explored possibilities in a disorganized and confused manner often repeating elements of concern. This behavior resembled the brainstorming activity characteristic of the preparation phase of creative thinking. The protocols of these subjects were the longest of all the subjects' protocols and they seemed to be more willing to engage themselves in the problem tasks.

Several subjects appeared unwilling to become personally involved in the problem tasks. Problems suggested were specific to a particular field experience and solutions were step-by-step textbook responses.

Two subjects attempted the task initially and then indicated that because of lack of knowledge and experience they did not feel comfortable responding. Dissatisfaction with the problem statement affected the response of one field independent subject. The subject misinterpreted the statement and rewrote it to fit the interpretation desired. The subject never did engage in the task as presented.

No significant differences were found between field independent and field dependent subjects on the ill-structured problem. An investigation of the protocols indicated that subjects varied on their willingness to personally engage themselves in the problem tasks. Motivation or need to solve a particular problem has been shown to affect the ability to represent problem information which is essential if a reasonable solution is to be reached (Greenfield, 1987); (VanGundy, 1981); (Bloom and Broder, 1950).



## SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

This study was conducted to compare the metacognitive behaviors of field independent-dependent subjects on three types of problem solving tasks.

The Group Embedded Figures Test was administered to one hundred and two (102) pre-service teachers to assess levels of field independence-dependence. Forty-six (46) subjects were identified as field independent and twenty-four (24) were classified as field dependent. The study sample of thirty-four (34) subjects was randomly selected from these groups.

Subjects were presented three problems which varied in inherent structure. Subjects' think aloud statements were tape recorded and transcribed. These think aloud protocols were analyzed using a coded analysis technique.

The Checklist of Metacognitive Behavior was the classification system used to perform the coded analysis of the subjects' protocols. Criterion behaviors located in the protocols were identified from surface language structure and assigned points for the first occurrence. Analysis of variance was used to compare mean scores from the CMB on each problem for the two cognitive style groups.

Significant differences were found between field independent and field dependent subjects for total and category scores on problem number one. Results supported the rejection of hypothesis one ( $H_1: u_{FI} > u_{FD}$ ).

Data analysis yielded no significant differences between groups

on total or category scores for problems two and three. Hypotheses two ( $H_2: u_{FI} = u_{FD}$ ) and three ( $H_3: u_{FI} = u_{FD}$ ) were retained.

### Conclusions

#### Problem One

Field dependents had difficulty with all three structured problems. Only one of the four field dependents solved the Tower of Hanoi problem correctly. Field dependents had more trouble representing information, were less likely to diagram problem elements or to re-read sentences containing relevant cues. Field dependents exhibited fewer monitoring and evaluation behaviors during the problem solving process regardless of the way the problem was presented. Results of the data analysis for the structured problems support past and current research indicating that field dependents have difficulty restructuring material to plan and carry out problem solutions.

However, the possible negative impact of complicated written instructions is supported by the findings of significant differences between field independents solving the Tower of Hanoi problem and those solving the Monsters and the Globes problem. Previous research has indicated that field independents' cognitive structuring ability is superior to field dependents for both visual and verbal tasks (Witkin, et al., 1977). Results of the field independents' performance on the Monsters and the Globes suggest that field independents also may experience difficulty structuring complex, abstract written instructions.

Both cognitive style groups also failed to use the three

criteria in the Monsters and the Globes problem when monitoring and evaluating the success of their strategies. Both field dependents and field independents concentrated on only two of the criteria or rules. Subjects checked only Rules #1 and #2 together or Rules #1 and #3 together. Rule #2 states that if a monster is holding two globes, only the larger of the two may be transferred. Rule #3 states that a globe may not be transferred to a monster who is holding a larger globe. Subjects may have merged these two rules because of the similarity in language. It is also possible that reading the two rules, one after the other, the subjects may have been unable to hold both ideas in short term memory simultaneously. The combination of Rules #1 and #2 and Rules #1 and #3 may have been the primary focus because there was less strain on working memory when using these constraints.

Random trial and error was the strategy used by all subjects regardless of cognitive style. When subjects became aware of errors in their strategies, they went back to the original problem state rather than starting from the previous state. Subjects, especially those individuals working with the Monsters and the Globes problem, had difficulty keeping their place in the problem sequence.

Monitoring problems were particularly apparent for those subjects who did not diagram or made poor use of their diagrams of the problem elements. Most individuals, regardless of style, used arrows to indicate changes in the problem state. However, they often became confused because they neglected to label each move. Tracking was difficult and so the subjects would start from the beginning which required more time and effort.

The practice of returning to the original problem state each time an error was spotted may have influenced the subjects' willingness to persist in the problem solving activity. Despite the fact that individuals could pace themselves and no time constraints were placed on the subjects, no subject in either group working on the Monsters and the Globes remained engaged in the task for more than fifteen minutes.

Individuals who solved the Tower of Hanoi problem manifested more monitoring and evaluating behaviors than those who failed to solve the problem. Field independent subjects who were successful on the Tower of Hanoi problem used a greater number and variety of monitoring and evaluation behaviors than field independents working on the Monsters and the Globes problem. While differences existed between cognitive style groups on planning and affect for the Tower of Hanoi problem, the primary areas of differences in metacognitive behavior involved monitoring and evaluating legal moves toward the problem solution.

#### Problem Two

There were no significant differences on the semi-structured problem between field independent and dependent subjects. Subjects from both cognitive style groups who received high scores on the CMB exhibited similar behaviors. In contrast to field independent and dependent subjects with low scores, high scoring subjects appeared to realize that it was possible for the problem solver to restate or redefine the problem and its elements in order to effect a solution. These individuals changed the initial statement into

either a command ("Make an outline for a presentation.") or a question format ("What would you say to students about student life on campus.") which allowed them to plan and carry out a solution to the problem. They redefined the statement to reflect a problem situation that was recognizable and solvable.

Low scoring individuals expected direction from the problem statement and finding the statement lacking in direction could not recognize the existence of a problem. Several subjects examined the text for syntactic and semantic errors hypothesizing that the problem was incorrectly worded. Protocols of these individuals did not suggest that the subjects had considered a redefinition of the problem that would make sense to them.

Redefinition of problems before attempting to find a solution is often required in the academic problems that students must solve in school. In real life problems redefinition is generally necessary to make problems manageable and solvable. Awareness of the possibility of problem redefinition allows the individual some measure of control over problem solution. Understanding and use of this strategy or approach to vague or ambiguous problems is an important factor in arriving at reasonable or workable answers to problem situations. Absence of this strategic knowledge from an individual's repertoire of cognitive strategies may influence the ability to recognize the existence of a problem state.

### Problem Three

Problem three involved subjects in both problem formulation

and problem solution. Individuals exhibited similarities in behavior but cognitive style preference did not appear to influence the metacognitive behaviors observed.

Both field independents and dependents who were willing to engage themselves in the problem tasks participated in a brainstorming type process to identify a significant educational problem. These subjects also indicated that they would need the assistance of other people and more knowledge than they now possessed to come to an adequate statement of the problem. They also recognized that the problems that they considered significant could not be solved by one individual teacher.

Real life problems in all occupations are most usually defined and solved in cooperative teams or groups. Each member contributes knowledge and a unique interpretation of the situational variables. Problems are identified by using brainstorming, listing alternative perceptions, metaphors or analogies, etc (VanGundy, 1988). The emphasis in the problem finding stage is creative or divergent processes. The subjects described above remained in this phase of the problem task.

Subjects who spent a brief period of time with this task engaged only in convergent processes. A problem was immediately stated and previously learned ideas were applied to the solution. These were stated briefly and precisely.

Open-ended or ill-structured situations often render predetermined strategies useless to problem identification and/or to problem solution. These types of situations require individuals to improvise or create new solutions (VanGundy, 1988).

### Recommendations

1. Training studies suggest that instruction in metacognitive behavior related to reading comprehension can improve student comprehension and overall achievement (Baker and Brown, 1984). Training studies have not been conducted to instruct pre-service teachers in those metacognitive behaviors that relate to problem solving. Comparisons of the metacognitive behaviors of field independent-dependent pre-service teachers after explicit instruction in metacognitive behaviors associated with problem solving would provide information concerning the malleability of style preference.
2. Research in the perceptual aspects of problem solving has suggested that initial perceptual activity provides significant information to be used during the problem solving process (Simon, 1979). When presented with a visual field, field independents are able to quickly organize or re-organize elements. Comparisons of the metacognitive behavior of field dependent and field independent persons solving structured problems written in simple language and accompanied by a visual representation would provide information about field independent problem solving under conditions in which research indicates that they have superior ability.
3. The present study compared the observed metacognitive behaviors of field independents-dependents in specific problem solving situations. However, the subjects were not evaluated on their metacognitive knowledge prior to solving problems.

Comparisons of subjects' metacognitive knowledge of problem solving with actual metacognitive behavior would add to the understanding of problem solving and metacognition.



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## APPENDICES

## APPENDIX A

CONSENT FORM

PLEASE READ CAREFULLY BEFORE SIGNING

Your participation is requested in a research project conducted by Maureen Carr. The results and conclusions drawn from the results of this project will be included in the researcher's doctoral thesis.

PARTICIPATION IN THIS STUDY IS COMPLETELY VOLUNTARY!

The Group Embedded Figures Test will be administered to all participants to determine degree of field independence-dependence. A sample group of 30 subjects will be randomly selected from the individuals taking the test.

The 30 subjects will be involved in three problem solving sessions. Trained assistants will tape the subjects verbal descriptions of their problem solving procedures. Assistants will provide practice problems for subjects so that they may become comfortable with the think aloud procedure.

Taped verbalizations will be transcribed and the content analyzed by the researcher. Subjects' names will be replaced with letter codes after taping sessions have been completed. Data from all the subjects will be pooled for statistical analysis. Portions of coded transcripts will be used in the doctoral thesis as examples or illustrations of the results.

IF YOU HAVE ANY QUESTIONS OR CONCERNS RELATED TO THE RESEARCH PROJECT, PLEASE CONTACT:

Maureen Carr  
Ed Hall 420  
737-3648

I understand the requirements of this research and I volunteer to participate.

Signature \_\_\_\_\_

Date \_\_\_\_\_

## APPENDIX B

CHECKLIST OF METACOGNITIVE BEHAVIORPLANNING

1. Read the problem statement completely.
2. Clarified terms and data.
3. Recognized the existence of a problem.
4. Recognized the solvability of the problem.
5. Recognized that all elements required were/were not included.
6. Recognized that the problem did/did not require redefinition.
7. Did/did not use relevant prior knowledge.
8. Did/did not use problem statement to define the problem.
9. Determined relevant data.
10. Determined adequacy of information provided.
11. Represented the information graphically.
12. Represented the information verbally.
13. Represented information visually.
14. Developed a goal statement.
15. Generated ideas/operations to reach goal.
16. Examined options.
17. Selected the idea/operation with the most potential for success.
18. Developed a sequence of steps to reach the goal.
19. Predicted possible results of idea/operation.
20. Established criteria for evaluation.

MONITORING

1. Used established criteria to check progress.
2. Aware of place in plan or sequence.
3. Aware the plan was/was not working to achieve goal.
4. Aware that changes in the plan were/were not required.
5. Aware that subdividing would/would not facilitate solution.
6. Aware that other information was/was not needed.
7. Aware that a reasonable solution was/was not reached.

EVALUATION

1. Determined that the problem was solved.
2. Judged the accuracy of results.
3. Evaluated the efficiency of the solution.
4. Evaluated the effectiveness of the solution.

AFFECT

1. Concentrated sufficiently to understand the problem.
2. Willing to spend time planning a solution.
3. Recognized the importance of the reasoning process.
4. Completed the reasoning process before terminating problem solving.
5. Confident in ability to solve the problem.
6. Looked at the problem objectively regardless of personal values.
7. Maintained attention regardless of external distractions.
8. Confident in the correctness/feasibility of the solution.



## APPENDIX C

STRUCTURED PROBLEMSTOWER OF HANOI

This is a puzzle type problem which involves three posts and three disks of graduated sizes. The disks are arranged on the left post in pyramid fashion. Move the disks to the right post so that they are in the same pyramid form with the following two constraints: 1) move only one disk at a time and 2) do not put a disk on top of a disk smaller than itself.

MONSTERS AND GLOBES

Three five-handed extraterrestrial monsters were holding three crystal globes. Because of the quantum-mechanical peculiarities of their neighborhood, both monsters and globes came in exactly three sizes with no others permitted: large, small and medium. The medium monster was holding the small globe; the small monster was holding the large globe; the large monster was holding the medium-sized globe. Since this offended their keenly developed sense of symmetry, they proceeded to transfer globes from one monster to the other so that each monster would have a globe proportionate to his own size.

Monster etiquette complicated the situation since it requires that:

1. Only one globe can be transferred at a time.
2. If a monster is holding two globes, only the larger of the two may be transferred.
3. A globe may not be transferred to a monster who is holding a larger globe.

By what sequence of transfers could the monsters have solved this problem?

TEA CEREMONY

In the inns of certain Himalayan villages is practiced a most civilized and refined tea ceremony. The ceremony involves a host and exactly two guests, neither more nor less. When the guests have arrived and have seated themselves at the table, the host performs three services for them. These services are listed below in the order of the nobility which the Himalayans attribute to them:

Passing the rice cakes  
Pouring the tea  
Reciting poetry

During the ceremony, any of those present may ask another, "Honored, Sir may I perform this onerous task for you?" However, a person may request of another only the least noble of the tasks the other one is performing.

Further, if a person is performing any tasks, then he may not request a task which is nobler than the task he is already performing. Custom requires that by the time the tea ceremony is over, all the tasks will have been transferred from the host to the most senior member of the guests. How may this be accomplished?

#### SEMI-STRUCTURED PROBLEM

You have agreed to speak to 50 high school seniors about student life at Oregon State University. The presentation is to be 20 minutes followed by a 10 minute question and answer period.

#### ILL-STRUCTURED PROBLEM

State a significant problem that you will face as a classroom teacher.

How will you solve this problem?

## APPENDIX D

PRACTICE PROBLEMS

1. Some months have 31 days; some have 30 days. How many have 28 days?
2. Without lifting your pencil, draw through all nine dots using only four straight lines.

```

      *      *      *
      *      *      *
      *      *      *

```

3. DONALD  
 + GERALD  
 -----  
 ROBERT

Each letter represents a digit: 0-9.

D = 5

Assign digits to the letters so that when the letters are replaced by corresponding digits the sum is satisfied.

4. In this game of solitaire, each of the cards has a one-digit number on the side turned down. Numbers 1-9 appear on the cards. The numbers of the 4 corner cards are odd numbers. Row 1 contains consecutive odd numbers. One of the diagonals contains prime factors of 84. Numbers in Column 1 are factors of 72. The Column 3 total is twice the Row 1 total. the Column 1 total is equal to the Row 3 total. What digit is on each card?

```

Cards:      *      *      *
            *      *      *
            *      *      *

```