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THE RELATIONSHIPS BETWEEN COGNITIVE ABILITIES, DEMOGRAPHIC VARIABLES, INFORMATION PROCESSING, AND PROBLEM SOLVING PERFORMANCE IN AN ADULT POPULATION

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THE RELATIONSHIPS BETWEEN COGNITIVE ABILITIES, DEMOGRAPHIC VARIABLES, INFORMATION PROCESSING, AND PROBLEM SOLVING PERFORMANCE IN AN ADULT POPULATION

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Eleanor Mannino Reibel, B.S., M.S.

** ** ** **

The Ohio State University
1982

Reading Committee:  
William D. Dowling  
Philip M. Clark  
John C. Belland

Approved By  
[Signature]

Adviser  
College of Education
This research effort is dedicated to my loving husband, Kurt, and my children. Without their encouragement and support, the task would have been much more difficult.
ACKNOWLEDGEMENTS

I wish to thank the following people for their cooperation, assistance and contributions.

Thanks to the faculty of The Ohio State University and Kent State University Schools of Nursing who took the time to participate in the study.

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A sincere thanks to my major advisor, Dr. William Dowling. Not only has he provided me with guidance and advice, but he has fostered my growth and development as an adult learner.

Special thanks to Dr. Philip M. Clark and Dr. John C. Belland for their time and effort in helping me become a better researcher.
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Publications


Reibel, E. Mandatory Continuing Education for Relicensure of Nurses-Yes or No? Columbus, Ohio: Ohio Nurses Association, 1981.
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CHAPTER I

INTRODUCTION

Background of the Problem

Decision making and problem solving are fundamental activities of all teachers. Teachers make decisions outside the classroom about why, how, what and when they will teach various aspects of class content. They make judgments about the learning progress of their students. They make interactive decisions in the classroom when answering student questions and carrying out classroom activities. The teacher has been described as a problem solver (Joyce and Harootunian (1964), decision maker (Shavelson, 1973), clinical information processor (Shulman and Elstein, 1975) and as planner (Clark and Yinger, 1977). Whatever the label used to describe the problem solving function of teachers, the thinking process underlying this activity influences the direction, quality and quantity of resulting solutions.

Clark (1978) describes research on teacher thinking as proceeding along two lines of inquiry—those studies based on a decision making model and those using an information processing model. Studies which have used a decision making model focus on a description of problem tasks performed by the teacher such as problem recognition, problem definition, planning, formulation of action alternatives, decision choice implementation and assessment of consequences (Zaborik, 1975; Peterson,
Marx and Clark, 1978). The information processing approach is concerned with the study of mental processes occurring during the performance of problem solving tasks. Specifically, these include sensory input, language and pattern recognition, sensory and memory interface, information storage and retrieval hypothesis production and the generation of novel solutions (Rumelhart, 1977). The studies done by Marland (1977) examining the interactive thoughts of teachers, and by Shavelson (1977) exploring teacher sensitivity to the reliability of information in making pedagogical decisions utilize the information processing approach. According to Clark (1978) much more research is needed to achieve a better understanding of the covert thought processes which influence the overt behavior of teachers.

The ubiquitous nature of problems has served as a stimulus for psychologists, sociologists, educators and others to seek an explanation of what problems are, how problem solving is done, and how best to train people to optimize problem solving performance. The complexity of the task can be attested by the many studies that have been done exploring every facet of this mental activity. There are three major areas of research each containing a multitude of variables. The environment in which problem solving occurs has been found to affect the kinds of problems encountered, information available to solve problems, strategies used in solving problems, perceptions of risks to be taken and aspirations to reach a desired goal (Hamptom, Summer and Webber, 1973; Keen, 1973; MacCrimmon and Taylor, 1976). The problem itself affects the ease or difficulty of arriving at a solution, demands on the cognition system, and the strategies used to solve problems (Newell and
Simón, 1972; Greeno, 1978; McKenney, 1973). Finally attributes of the problem solver are a crucial consideration in problem solving situations. Developmental level, cognitive, affective and psychomotor skills, cognitive style, previous experience and level of motivation affect the way an individual formulates the problem, processes information and arrives at solutions (Johnson, 1972; Keen, 1973; Scandura, 1977; Allwood, 1977).

The scope of problem solving research cannot be dealt with adequately in a brief description. The intent above was to give the reader an idea of the many factors which are considered in problem solving research. The present study focuses on the individual problem solver, specifically, the relationships between cognitive abilities, demographic variables, problem solving activity, and performance. The conceptual framework, which follows, narrows the focus and leads to the specific questions to be addressed in this research.

**Conceptual Framework**

The incentive for the present research was sparked by personal observation, both in the United States and abroad, that teachers vary considerably in their ability to solve problems. There seemed to be two reasons for this difference. First, teachers appeared to differ in their level of cognitive skills, i.e., comprehension, reasoning, fluency of ideas, etc.; and secondly, they appeared to differ in the way they gathered and used information. From these observations several general questions emerged which served as a basis for a review of the literature.
1. What effect do cognitive skills have on problem solving?
2. What effect does information gathering and information manipulation have on problem solving?
3. To what extent do cognitive skills affect information processing?

In reviewing the literature on cognitive abilities a series of studies done by the Aptitude Research Project (Merrifield et al., 1962; Guilford and Hoepfner, 1972) had special significance. This group identified five phases of problem solving—preparation, analysis, production, verification and reapplication, and proceeded to identify abilities which were essential to each phase. They concluded that the preparation and analysis phase depend heavily on cognition and memory, especially cognition of semantic implications. The production phase depends heavily on ideational fluency, spontaneous flexibility, associational fluency and a production of a variety of changes of interpretation. In addition, convergent abilities were necessary to generate answers. Evaluation abilities were necessary throughout the problem solving process for verification and reapplication of emerging ideas. Other investigators confirmed or added the following abilities—logical thinking and the ability to form concepts (Houtz, Ringenbach and Feldhusen, 1973), verbal ability (Hunt, Frost and Lunneborg, 1973), ideational fluency and the ability to organize and evaluate various problem elements in proper order (Houtz and Speedie, 1978), and thinking flexibility (Houtz, Montgomery and Kirkpatrick, 1979).
The research review indicated that, indeed, many abilities appeared to influence problem solving. Clearly, some organizing framework would be necessary to identify essential, yet manageable numbers of abilities to be investigated. In 1980, Diamond and Royce proposed a hierarchical model of the cognition system in which three fundamental classes (conceptual, perceptual and symbolizing) of psychological processes exist. Subsystems are described in terms of primary and secondary abilities. The second level factors, under each of the three classes contained all of the identified abilities in the problem solving literature, and at the same time were a reasonable number of variables to deal with in the research. They included the verbal and reasoning factor of the conceptual class, the spatiovisual and memorization factor of the perceptual class and the fluency and originality factor of the symbolizing class.

The development and refinement of psychometric tests to measure cognitive abilities dates from the early part of this century, with attempts by Binet, Spearman and others to measure intelligence. Carroll and Maxwell (1979) state that "a series of well designed factor analytic studies have produced solid and generally replicable information on major dimensions by human cognitive ability at various levels of generality" (pg. 607). The Educational Testing Service (ETS) Kit of factor referenced tests was recently revised to provide investigators with readily available tests for research on cognitive abilities (Ekstrom, French and Harman, 1976). Tests were selected from the ETS kit which were representative of the second level factors identified by Diamond
and Royce (1980). They include tests of the following factors: verbal comprehension, inductive reasoning, visualization, integrative processes, ideational fluency and originality.

The information processing literature is vast and covers many levels of thinking. Carroll (1971) has suggested that cognitive abilities are the very essence of information processing and has set about the task of describing the mental process utilized in each of the cognitive abilities. Cognitive abilities are viewed as static constructs in which carefully circumscribed mental activity is not only measured quantitatively but is described operationally. Messick states that "ability dimensions essentially refers to the content of cognition or the question of what—what kind of information is being processed, by what operation, in what form" (1978, p. 7). Cognitive strategies and cognitive styles deal with information processing at a more general level and focus on how information is acquired and manipulated. Messick (1978) distinguishes between the two, noting that strategies vary from situation to situation, whereas, cognitive styles have a more pervasive influence affecting behavior consistently over a variety of situations. Royce (1973), in his multifactor theory of individuality suggests that cognitive styles are higher level factors which are combinations of cognitive, affective and personality dimensions.

Keen and McKenney (1973) building on the research of Bruner, Goodman and Austin (1956), Broadbent (1971) and others proposed an information processing model. A revision of the model by Keen (1973) appears in Figure 1.
The model identifies two dimensions in processing information. The information gathering dimension is concerned with the process by which the individual gathers and organizes the diffuse verbal, visual, auditory, and tactile stimuli for storage in short and long term memory. The information evaluation dimension is concerned with methods of retrieval and manipulation of information for problem solving purposes. In gathering information, the preceptive thinker is more likely to develop categories in which to place incoming data; while the receptive thinker gathers data in a sequential manner, before determining the implications of the collected data. The systematic thinker is likely to approach a problem by structuring it in terms of some method which will lead to solution. The intuitive thinker approaches the problem with a number of hypotheses, quickly testing the idea until the "right" one becomes obvious. According to Keen (1973), individuals will habitually gather information in a preceptive or receptive manner and manipulate information in a systematic or intuitive manner. As such, the McKenney-Keen model can be viewed as an information processing style.
Carroll (1978) notes that there have been few attempts to study the relationship between cognitive abilities with strategies used by subjects in accomplishing a task. Using data from a study by Fredericksen (1969), Carroll was able to demonstrate that those subjects who scored higher in associational fluency do particularly well in free recall learning if they adopt a strategy of using "order preserving mnemonics" (such as trying to make a sentence from words rather than attending to the sounds of words in a learning task). The purpose of this exercise by Carroll was to illustrate the future potential of this research. The implication for the present research is that it raises the question of a possible relationship between performance on one or more of the ability tests with one or more of the information processing modes identified by Keen (1973).

Ages and educational level emerged in the literature review as additional factors to consider in the study of problem solving. Studies examining the relationship of age with abilities, show that those abilities identified with crystallized intelligence (verbal fluency, verbal memory, number facility) decrease much later in life and at a slower rate; while those abilities associated with fluid intelligence (spatial ability, inductive reasoning and fluency) are more likely to decline earlier and faster. (Horn and Cattell, 1967; Nesselroade, Schaie and Baltes, 1974; Schaie and Labouvie-Vief, 1974; Horn, 1976). Several studies demonstrate that nonverbal (fluid) intelligence is the best predictor of problem solving ability in middle and older aged individuals (Wetherick, 1964; Kesler., Denney and Whitey, 1976). Green (1969) found that the higher the educational level the more
likely that intellectual abilities would be maintained into later years. Since the ages of teachers in this study range from the twenties to the sixties, and, since educational credentials vary to a more limited degree, the effects of age and educational background on cognitive abilities and problem solving will be examined. In addition, years of teaching experience and the subjects taught by teachers will be included in the study.

In summary, the ensuing investigation focuses on the relationships of problem solver attributes and problem solving behaviors. The selected variables gleaned from the literature fall into four categories and are listed below in Figure 2.

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<td>Educational level</td>
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<td>Mode - preceptive, receptive,</td>
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<tr>
<td>solution</td>
<td>systematic, intuitive</td>
</tr>
<tr>
<td>Time to problem completion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Style - preceptive-systematic</td>
</tr>
<tr>
<td></td>
<td>preceptive-intuitive preceptive-systematic</td>
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<tr>
<td></td>
<td>receptive-systematic</td>
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<td></td>
<td>receptive-intuitive</td>
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Figure 2. Complete List of Variables Used in the Study.
Definitions


2. Cognitive Ability: an individual difference variable which delineates "what kind of information is being processed by what operation and in what form" (Messick, 1976, p. 7). It is also referred to as a skill or factor.

3. Cognitive Style: an individual difference variable which refers to habitual or characteristic modes of behavior.

4. Decision making: Decision making is considered a subset of problem solving, in that decisions deal primarily with evaluation and choice of alternatives within the problem solving context.

5. Educational level: The highest educational credential obtained by the subject as reflected in bachelors, masters or doctorate degree. This is also referred to as highest earned credential.

6. Ideational fluency: "Ability to quickly produce ideas and exemplars of an idea about a stated condition or object" (Royce, 1973, p. 377).

7. Inductive reasoning: "Ability in forming and testing hypotheses directed at finding a principle or relationship among elements, and applying the principle to identify an element fitting the relationship" (Royce, 1973, p. 377).
8. **Information processing mode:** one of four ways of thinking described by Keen (1973, pp. 24-25).

**Preceptive** - A preceptive thinker is one who looks for cues in a set of data, focusses on patterns of incoming data building a set of explanatory precepts.

**Receptive** - A receptive thinker incrementally compiles units of information before arriving at conclusions.

**Systematic** - A systematic thinker consciously plans on a method for solving a problem and proceeds to handle the information in discrete steps.

**Intuitive** - An intuitive thinker considers a number of alternatives and options simultaneously while keeping the overall problem continuously in mind.

9. **Information Processing Style:** A two dimension cognitive style in which individuals can be described as having a propensity to gather information in a preceptive or receptive manner and manipulate information in a systematic or intuitive manner. As such there are four possible information processing styles: preceptive-systematic, preceptive-intuitive, receptive-systematic and receptive-intuitive. Expected behaviors are combinations of those listed under information processing mode above.
10. Integrative processes: "The ability to keep in mind simultaneously or to combine several conditions, premises or rules in order to produce a correct response" (Ekstrom, French and Harmon, 1976, p. 87). The ability is similar to associative memory (Royce, 1973).

11. Originality: "Facility in conceptualizing phenomena in ways that in our culture are judged to be unusual or clever" (Royce, 1973, p. 378).

12. Problem solving: includes all the thoughts on actions that occur when an individual is called on to perform a task not previously encountered, and for which there is no readily available solution.

13. Problem solving success: an individual who is able to solve the Nine Square Problem within a fifteen minute period is considered successful.

14. Problem solving time: the length of time (in half minute intervals) it takes for successful problem solvers to obtain the correct answer.

15. Subject taught: one of four general categories of subject matter taught by nurse educators. They include medical-surgical nursing, maternal-child health, community health, psychiatric, and administrative concepts.

16. Teaching experience: the number of academic years of teaching in a school of nursing, as of June 1981.

18. Visualization: "the ability to manipulate visual percepts (to imagine change in forms) and thus 'see' how things would look under altered conditions" (Royce, 1973, p. 377).

**Statement of the Problem**

Teachers are adults who are confronted daily with all kinds of problems; yet research seeking to understand the teacher as problem solver is minimal. The overall goal of the present study is to examine, in a somewhat exploratory fashion, the relationships between cognitive abilities, biographical variables, information processing activity and problem solving performance. The intent is to gain further insight into individual differences that affect problem solving behavior.

To assist in limiting the scope of the study and to provide direction for the examination of relationships, the following investigation will focus on three major questions.

1. **Is there a significant relationship between subjects' performance on selected cognitive ability tests, specified demographic variables, information processing modes and problem solving performance?**

2. **Do high and low level performers on cognitive ability tests differ in the way they process information?**
3. How do successful and unsuccessful problem solvers differ in terms of selected cognitive abilities, specified demographic variables and information processing style?

Assumptions

1. The first and most important assumption is that cognitive abilities are recognized by psychologists as legitimate constructs for which valid and reliable instruments exist for their measurement.

2. Extraneous, yet confounding variables have been considered. Age, educational level and years of experience are variables examined in the study. Since less than 1% of the nurse educator population is male, only females are subjects in the study. Motivation and co-operative effort are distributed normally across the sample.

3. All faculty at the two schools involved in the study received general information about the research during the solicitation phase. During the first three of four data collecting sessions, participants were asked not to share information about their activities until data collection was completed. The assumption, therefore, is that all subjects participating in the study come with the same information.

Limitations: The limitations of this investigation are:
1. The sample will be limited to fifty-four nurse educators in two schools of nursing in Ohio (Kent State University and The Ohio State University). Comparisons of national, school and sample nurse educator populations are made in Chapter III for those demographic variables for which information is available. Generalizability of the findings should be made in light of the comparisons and the sample size.

2. Random sampling was not possible as subjects volunteered for participation in the study. Comparisons are useful in determining the representativeness of the sample population to school and national populations.

3. Since subjects were aware of participation in a research project the possibility of the Hawthorne effect exists.

Hypotheses

Questions raised in the problem statement and in the review of the literature led to the formulation of the following hypotheses. They are stated in the null form.

Hypothesis 1: None of the following variables will exhibit first order correlations with any of the others in a significant manner:
The subject's position on each of the cognitive factors:

(a) verbal factor as measured by the Extended Range Vocabulary Test
(b) reasoning factor as measured by the Letter Sets Test
(c) spatio-visual factor as measured by the Paper Folding Test
(d) associative memory factory as measured by the Calendar Test
(e) fluency factor as measured by the Symbols Test
(f) originality factor as measured by the Different Uses Test

and the subject's

(g) chronological age
(h) years of teaching experience
(i) educational level

and the subject's response on a questionnaire measuring the extent of

the

(j) preceptive information processing mode
(k) receptive information processing mode
(l) systematic information processing mode
(m) intuitive information processing mode.

**Hypothesis 2**: Performance on any of the six cognitive ability tests will not contribute significantly to the explanation of time taken by subjects to successfully solve the nine square problem.

**Hypothesis 3**: There is no significant correlational relationship between subjects who score high and low on each the cognitive ability tests and the information processing mode used by those subjects.

**Hypothesis 4**: There is no significant difference between performance of subjects on cognitive ability tests and their:

(a) success or failure in solving a problem
(b) information processing styles
(c) subject taught
Hypothesis 5: There is no significant correlational relationship between the chronological age of subjects and their success or failure in solving a problem.

Hypothesis 6: There is no significant difference between the information processing style used by subjects and their success or failure in solving a problem.

Overview of the Dissertation

The intention of Chapter I was to provide background information about the problem being investigated, a conceptual framework for the problem statement and a formulation of the research hypotheses. Chapter II will enlarge on some of the concepts presented earlier and review related literature and studies pertinent to the research. The research design and procedures used in the study are discussed in detail in Chapter III. They include a description of the population and sample, instruments used in the study, data collection and methods of analysis for each hypothesis. Analysis of data together with findings are reported and discussed in Chapter IV. A summary of the study, conclusions, interpretations and recommendations for further research are presented in Chapter IV.
CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Problem solvers bring to a problem situation varying levels of cognitive skills and a set of response habits or cognitive styles shaped by previous experience. Cognitive skills are representative of what capabilities exist in an individual, while information processing styles are concerned with how incoming data are perceived, encoded, retrieved and manipulated. The purpose of this research is to explore how individuals, with specific capabilities, gather and manipulate information while solving a problem, and which abilities are related to problem solving performance. Selected demographic variables will also be examined in terms of cognitive skills and problem solving activity.

The review of the literature elaborates on concepts introduced in the previous chapter and provides additional insights into the theory and research posed by the questions in the problem statement. The following main sections serve to organize Chapter II.

A. Cognitive abilities and problem solving

B. The use of problems in research

C. Information processing and problem solving

D. The effect of demographic variables on abilities and problem solving

E. Summary
Cognitive Abilities and Problem Solving

The classic concern of psychometric theory has been to understand the nature of intelligence. Historically, the effort to identify measure and describe mental abilities date from the turn of the century with studies by Binet, Spearman, Cattell and others (Carrol and Maxwell, 1979). There are many proposals about the number and interrelations of abilities but these generally fall into three approaches. Spearman hypothesized a general factor of intelligence (g) which later was elaborated into a hierarchical structure such as that of Cattell's (1971) theory of fluid and crystallized intelligence. Guilford (1967) and associates proposed a facet model which proposes that all mental functioning can be described as combinations of one of 5 kinds of mental operations (cognition, memory, convergent and divergent thinking and evaluation), with one of four kinds of content (figural, symbolic, semantic and behavioral), with one of six kinds of products (units, classes, relations, systems, transformations and implications). For example, the ability to think of a number of things categorized as "red" could be expressed as a trigram DMU or divergent production of semantic units. Diamond and Royce (1980) proposed a model of the cognition system in which three fundamental classes (conceptual, perceptual and symbolizing) of psychological processes exists. Subsystems are described in terms of primary and secondary mental abilities subsumed under the three classes. This model is hierarchical in nature, but contains the Guilford primary abilities.

There are proponents and critics of each of the three approaches. Undheim and Horn (1977) have presented cogent arguments for questioning
the Structure of Intellect (SI) model of Guilford on the basis of the rotation of factors to achieve substantiation of hypothesized directions of ability factors. In their book, Cronbach and Snow (1977) go to considerable lengths to demonstrate the instability of individual factor measurements across studies and the paucity of studies showing consistent relationships of abilities to treatment manipulation. Nevertheless, Cronbach and Snow as well as others (Carroll, 1976; Horn, 1976; Diamond and Royce, 1980) have not abandoned the thesis that different abilities exist and can be demonstrated empirically.

The issue of perspective does influence the choice of ability factors selected for inclusion in research. To this point it will become clear, later, that the Royce model was used as a basis for the selection of ability factors. For now, a discussion of research of abilities and problems solving follows.

In the early 60's the Aptitude Research Project (Merrifield et al., 1962; Guilford and Hoepfner, 1971) began a series of studies by identifying five phases of problem solving:

1. Preparation phase— one in which the solver becomes aware of the problem and defines it.

2. Analysis phase— determines what data is to be gathered and does so

3. Production phase— generates solution alternatives

4. Verification phase— compares solutions with the goal and accepts or rejects them.
5. Reapplication phase—determines the quality of solution and returns to any one of the previous stages if necessary.

Through a series of factor analytic studies it was found that the preparation and analysis phase depend heavily on cognition and memory, especially CMI. The production phase studied separately by Merrifield et al. (1962) revealed that ideational fluency (DMU), spontaneous flexibility (DMC), associational fluency (DMR) and production of a variety of changes of interpretation (DMT) were essential abilities. Convergent abilities (NMI and NMT) were described as necessary to generate answers. Evaluation abilities (especially EMI) were found to be necessary throughout the problem solving process for verification and reapplication of the thought processes.

Dunham and Bunderson (1969) analyzed the relationship of performance of high school students on twelve ability tests with performance on concept learning tasks in which instructions for discovery concepts was given or withheld. Inductive reasoning (CFC, CSC and CSS) contributed to concept achievement under both conditions. General reasoning (CMS) also contributed; when rule instructions were given but when rule instructions were not given associative memory (MSI) was involved. This finding is in agreement with those of Lemke, Klausmeir, and Harris (1967) who found factors of induction, general reasoning, and verbal comprehension in concept learning. McNemar (1955) also found that good problem solvers were superior in word fluency (especially fluency in supplying words to fit meaningful criteria),
induction, deduction and in overcoming a "set" in the well known water jug problems.

Problems other than concept attainment have been studied from a cognitive ability perspective. Gavurin (1967) found that there were individual differences in the ability to handle representational systems. In comparing scores on a spatial ability test with success in solving anagrams the correlation was .54. When the letters were placed on tiles that could be physically rearranged, correlation between test scores and success was negligible, presumably because spatial representation was unnecessary. Aiken (1971) in reviewing studies of intellectual variables with mathematics achievement, found that, in the case of algebra problems, verbal comprehension, deductive reasoning, algebraic manipulative skill, number ability and adaptability to a new task were important abilities. In all mathematical problem studies, both semantic and figural aptitude contributed to performance in solving mathematics problems.

Houtz, Ringenbach, and Feldhusen (1973) investigated the relationship between a measure of problem solving ability (the Purdue Elementary Problem Solving Inventory) and tests of logical thinking, concept formation, language development, perceptual skills, response styles as well as measures of reading IQ and school achievement. High significant correlations were found between problem solving ability and logical thinking (.45-.51) and problem solving and the ability to form concepts (.31-.40). Correlations with IQ, reading, arithmetic problems and perceptual tests were moderate. Only correlations of problem solving and response style (locus of control) were negligible.
Hunt, Frost and Lunneborg (1973) sought relationships between psychometric test scores and the parameters of performance in certain learning and memory tasks. They found a significant relationship between verbal ability and the speed with which a person enters information into short term memory and between quantitative ability and the resistance to interference in memory tasks.

Houtz and Speedie (1978) attempted to identify a factor that could be labelled problem solving and yet was distinct from divergent thinking factors. The purpose was to describe processes likely to be involved in verbal maze problems and written simulation exercises. Ideational fluency consistently emerged as an important factor in problem solving tasks. However, another factor emerged which the investigators felt could be described as a problem solving factor, i.e., the ability to organize and evaluate various problem elements in the proper order to reach a solution. This conclusion is consistent with the idea that the individual problem solver is an information processor (Simon, 1979).

Houtz, Montgomery and Kirkpatrick (1979) sought to determine the relationship between evaluation abilities as measured by the Purdue Elementary Problem Solving Inventory and creative thinking skills of fluency, flexibility, originality and elaboration. They found that only flexibility scores appeared to maintain a small but relatively consistent relationship to the problem solving measure.

There are several conclusions to be drawn from the studies of the relationship between abilities and problem solving. First, there is no unitary problem solving ability. As in the early study of the
Aptitude Research Project, numerous abilities were found to be involved in various phases of problem solving (Guilford and Hoepfner, 1971). Though some investigators have argued that a general intelligence measure is a good predictor of interaction between abilities and treatments (Cooley, 1976; Cronbach and Snow, 1977), others continue to perceive that individual abilities can be delineated and linked to the problem solving process and that meaningful relationships can be identified at a more specific level. Though there are good arguments on both sides of this issue it is not yet resolved. Carroll (1976) has urged that cognitive ability tests be viewed as cognitive tasks that can be operationally defined in terms of structure, contents and control processes. The view espoused by Carroll is the orientation held by the investigator in this research. In the following discussion of the rationale for the choice of ability tests the orientation will be more obvious.

Choice of cognitive factors—The Diamond and Royce (1980) cognition model was used as a basis for the selection of cognitive factors to be used in this study. The model is an attempt to combine the research efforts of many and incorporate the multifactor approach of Guilford with the hierarchical structure of Vernon, Cattell, Horn and others. The cognition model proposes that individuals cognitively interact with their environment in three fundamental ways—conceptually, perceptually and symbolically. The conceptual category contains those abilities which reflect reality denotively. Included in this category are second level factors of verbal and reasoning abilities and primary
factors such as verbal comprehension and induction. The perceptual category contains factors whose reliability and validity can be checked in memory and includes primary abilities of spatial and memory abilities. The symbolizing category includes fluency and imaginativeness as second level categories. The primary abilities deal with those aspects of cognition which generate relationships based on a large stock of mental symbols.

**Conceptual-verbal factor**—According to Royce (1973) verbal ability is an understanding of English words, sentences and paragraphs and has been identified by Guilford (1967) as CMU and CMR, and by Horn (1976) as $G_c$ or crystallized ability. Carroll (1976) states that verbal comprehension is almost exclusively dependent on the contents of lexicosemantic long term memory. This ability is a necessary one in problem solving when an understanding of the problem, problem constraints, and goals depend on written and/or verbal instructions. According to Royce (1980) the strongest primary ability which loads on the verbal factor is verbal comprehension and such a test will be used in this research (See Appendix A). Both Johnson (1972) and Cronbach and Snow (1977) point out that this ability correlates well with measures of general intelligence. Spearman (1931) also felt that verbal analogy tests (CMR) were the best measure of "g", or general intelligence.

**Conceptual-reasoning factor**—Verbal ability is clearly dependent on the number of concepts in the individual's repertoire; reasoning abilities are concerned with the ability to abstract concepts, rules and general principles. Royce (1973) defines inductive reasoning
as the "ability to form and test hypotheses directed at finding principle relationships among elements and applying the principle to identifying an element fitting the relationship" (pg. 377). Cattell (1971) points out that there are deductive steps in every inductive reasoning act and has expressed doubts that general reasoning and induction are separate factors. In addition, logical evaluation components enter into the act when evaluation of response is required suggesting that this factor includes more than the factors (CSC, CSS, CFC) Guilford (1967) considers in this mental act. Horn and Cattell (1966) found that the reasoning factor represents fluid intelligence and has its strongest saturation in inductive reasoning. The Letter Sets Test which has been identified by Ekstrom et al. (1976) as an inductive reasoning factor test will be used in this research to obtain a measure of reasoning ability (See Appendix A). In describing the information processed in induction, Carroll (1976) states that success would depend primarily on available relevant hypotheses in long term memory. When concepts are not available the subject may resort to performing serial operations in short term memory to construct new hypotheses.

Perceptual-spatiovisual factor—Royce (1973) theorizes that visualization factor exists at the first and second order level and defines it as "the ability to manipulate visual percepts to see how things would look under altered conditions" (pg. 377). Horn (1965) demonstrated that visualization is a higher order factor which includes spatial ability, adaptive flexibility, speed of closure. According to the Guilford (1976) classification, it falls into the CFT category.
The Paper Folding Test will be used in this research to obtain a measure of visuospatial ability (See Appendix A). In the test subjects are asked to visualize how a piece of folded paper with holes punched in it will look after it is unfolded. According to Shepard and Feng (1972), a series of mental processes are engaged in, requiring analytical strategy in a series of operations, and a search for symmetry and planes of reflection as clues to the solution.

Perceptual-memorization factor—According to Royce (1980) "perceptual ability includes not only the ability to perceive in the narrow sense of the word, but the ability to visually manipulate the directly perceptible qualities of things" (pg. 40). Dependency on memory can range from pure rote memory tasks, such as recall of digit spans, to the manipulation of remembered materials and rules for solutions. Integrative process ability is an associative memory factor which utilizes both intermediate term memory and reasoning (Carroll, 1976; Ekstrom, French and Harman, 1979). The Calendar Test, used in this study, is one which requires the subject to follow a set of directions and rules to arrive at an answer (See Appendix A). According to the Guilford classification (1976) the ability tested is in the MSR category, indicating that mental constructs (numbers) are used to identify meaningful relationships.

Symbolizing-fluency factor—Royce (1980) makes a qualitative-quantitative distinction in the symbolizing category which separate fluency ability from originality ability. Fluency abilities are those mental activities which result in the generating of many ideas. These
include the divergent production abilities identified by Guilford (1971). There is some correlation with flexibility factors, since the more ideas the subject generates in his responses, the more opportunity there is for spontaneous flexibility (Royce, 1973). The Symbols Test used in this research is a figural form of the ideational fluency factor and requires the subject to produce a number of figures in response to a given stimulus (See Appendix A). According to Carroll (1976) the subject is required to search the long term memory for relevant associations to the presenting stimulus.

**Symbolizing—originality factor**—Originality is concerned not only with the fluency of ideas, but also with the quality of original and creative modes of thinking. In the Different Uses Test, used in this research, it is made clear to subjects that only different ideas are considered, so an evaluative aspect is attached to the measurement process (See Appendix A). Guilford and Hoepfner (1971) note that the test identifies those subjects who are not only facile at generating ideas (DFT), but can also demonstrate ability in producing alternative meaningful concepts (NMT). Ekstrom et al. (1979) in their recent study of divergent factors have confirmed that originality factors can be differentiated from associational fluency and figural flexibility but not from expressional fluency or semantic flexibility. They suggest that expressional competency is inextricably linked to creativity and originality.
The Use of Problems in Research

The problems used by researchers are as numerous as the investigators using problems in research. Generally the rationale for problem selection is based on the objectives of the research, as no commonly accepted system of categorization exists. Many problems are described by level of difficulty, using a number of criteria—amount of information initially presented to the subject, amount of information to be interpreted and manipulated, the number of subgoals to be achieved prior to the omnibus solution, the amount of distracting material embedded in the problem and the kind and number of solutions desired (Johnson, 1972; Allwood, 1976; Nickerson and Feehrer, 1975).

As early as 1958 Bartlett suggested a dichotomous classification of problems. Closed system problems were those in which all elements for solution are available within the problem statement and appropriate manipulation of the elements will result in problem solution. Such problems would include anagrams, chess, and concept formation problems. Open system problems demand that the problem solver seek additional information before problem solution can be achieved. As in Bartlett's taxonomy, the classification of defined and ill defined (Minsky, 1963), structured vs. ill-structured (Newell and Simon, 1972) and programmed vs. non-programmable problems are dichotomous in nature, and classify problems by structure, solution, and computer capability.

Thompson (1967) in describing decision making in organizations recognized two major factors affecting decision issues—the belief about cause and effect relations and preference regarding possible outcomes. Different problems exist which require different strategies to
solve depending on the degree of certainty on each of the two dimensions. They are illustrated below.

Possible Outcomes

<table>
<thead>
<tr>
<th>Perceptions about cause/effect relations</th>
<th>Certain</th>
<th>Uncertain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Certain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Uncertain</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Decision Types and Suggested Strategies
Thompson (1967, pg. 134-135)

Interesting analogies can be made between Thompson's categories and the McKenney taxonomy in Figure 4 below.

Information Acquisition
Perceptual Processes

<table>
<thead>
<tr>
<th>Information Manipulation</th>
<th>Known</th>
<th>Type I Planning</th>
<th>Type II Intelligence and Search</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual Process</td>
<td>Unknown</td>
<td>Type III Invention</td>
<td>Type IV Research</td>
</tr>
</tbody>
</table>

Figure 4. Taxonomy of Problem Classes
McKenney (1973, pg. 20)
Both are two dimensional in nature with two categories producing a four class taxonomy. Both are concerned with the necessity to modify problem strategy depending on the degree of certainty of information available. The difference occurs in the perspective used to determine problem categorization. Thompson's taxonomy uses criteria external to the problem, i.e., knowledge of cause and effect relations and outcomes; while McKenney considers criteria internal to the problem solver. Planning problems occur when the problem solver feels he understands both what information is relevant and how to operate on it. The focus is to arrange data in a form which is manipulated for problem solution. Intelligence and search type problems exist when the operations and methods required to reach a solution are known, but not the data involved. Search is necessary before information manipulation can begin. In a type III problem the individual feels he knows what data are relevant, but not how to manipulate them. The problem exists in finding a way to process it to arrive at a solution. In a research type problem neither the data nor manipulation method is known. There is a conscious search for facts and generation of concepts together with a development of a method for manipulating the information.

Greeno (1978) has proposed a typology of problems. In problems of inducing structure, the subject is expected to understand and describe relations between presented elements. Problems of transformation are those in which the initial situation is presented and the goal stated. The problem solver using means-end analysis solves the problem. Water jug problems studied by Luchins (1964) and puzzles such as the tower of Hanoi problems used by Newell and Simon (1972) are examples of
this type of problem. Greeno (1978) suggested that the subject must have an understanding of the initial problem state, use memory to derive meaningful concepts and understand what solution is desired. Problems of arrangements are those in which components are presented and the task is to find a combination of them that meets some criterion. Cryptarithmetic and anagrams are arrangement type problems. Combinations of types are also possible. Chess, for example, is a transformation of arrangement type problem, where skills in the two categories are required.

Speedie, Treffinger, and Houtz (1976) have compiled information from many sources in classifying and evaluating problem solving tasks. They have determined that tasks can be classified by task characteristics (ambiguity, number of solutions, complexity and experience type), by process activities (preparation, production and evaluation) and by outcome (number of solutions, time to solution and mental process measures). They suggest that problems be selected so that memory and experience do not interfere with the researcher's ability to reliably assess the problem solving process used by subjects.

The problem selected for this study is the Nine Square Problem (See Appendix B). The problem is one in which the subject is to place a number (1-9 used only once) in each of the squares so that three vertical, horizontal or diagonal numbers total fifteen. Using the classification of Bartlett, it is a closed system problem as all essential information appears in the problem statement. Using McKenney's classification it is an invention type problem because relevant data is known to the subject but method of manipulation probably is not.
Finally, according to Greeno the problem is one of transformation of arrangement type of problem.

The problem was selected for several reasons. First, every aspect of the cognitive system is used in its solution. Verbal comprehension is necessary to understand the initial problem state and goal. Reasoning skills are necessary to determine numerical and positional arrangements. Memory is necessary to keep problem constraints and goal in mind during the problem solving activity. Spatiovisual abilities will help the subject keep vertical, horizontal and diagonal numbers in meaningful arrangements. Generation of hypotheses and the evaluation of these possibilities in light of problem constraints will help the subject to achieve a satisfactory solution. Secondly, the transformation of arrangement or invention type problem is one that teachers face often in the work situation. For example, the problem is analogous to one in which the teacher must decide the content of a given unit or course of study, or the weighting of various course components for grade determination. Finally the problem was selected because the problem solving technique could be used easily by the subject to answer questions about information processing used in problem solving. This will be discussed further in the next section.

Information Processing and Problem Solving

Information processing is concerned with describing and explaining a variety of mental activities such as information acquisition, encoding, retrieval and decay of information in long term memory and the nature of the reasoning process (Forehand, 1972; Rumelhart, 1974).
Though the term emerged with its use in computer technology the study of information processing is as old as the study of the mind. Gestaltists have used this approach extensively in their studies of human problem solving. Koffka (1935) demonstrated the importance of figure and ground in affecting structure of perceptual and cognitive fields which in turn influence problem definition. Wertheimer (1945) stressed the reorganization of patterns rather than a piecemeal attack in the problem situation. Duncker (1945) and others showed that functional fixedness can interfere with the generation of alternative problem solutions. Bruner, Goodnow, and Austin (1956) studying the use of four strategies: simultaneous scanning, successive scanning, conservative focusing and focus gambling, found that conservative focusing was the most efficient strategy to reduce "cognitive strain."

The stimulus response (S-R) associationists insist on explaining behavior in terms of association between stimulus and response. Most modern behaviorists accept the existence of internal thought processes or mediating S-R processes, but they are used cautiously and always in accordance with the laws of elementary behavioral processes. Staats and Staats (1963) in their study of the progression of the thinking in geometry problems describe how at a particular instant in the problem solving process, the next response is under the control of present stimuli. Other researchers have sought to explain the essence of problem solving as a response controlled by discriminative cues in conjunction with external stimulus conditions called "instructional stimuli" by Goldiamond (1972) or "precursor responses" by Skinner (1972). Berlyne (1965) has outlined other areas of inquiry to be
explored—the sequential nature of processes that supplement the external stimuli, the patterning of mediating response sequences, and the intrinsically reinforcing properties of thought processes.

With the introduction of computer programs in the 1950's the study of information processing has taken a new direction. The computer program itself serves as a model for describing the flow of thinking during the problem solving process. The information processing theorist attempts to infer cognitive processes of participating subjects working within the detailed specifications of the computer program. As such, there are as many models as there are programs. Protocol analysis or man-machine interaction records serve as the vehicle for analyzing data and arriving at inferences.

Early efforts with computer models such as General Problem Solver sought to explore the subject's goal determination and methods for achieving that goal. This study established the importance of problem structure and the efficacy of means-end analysis to achieve problem solutions (Newell and Simon, 1972). Bobrow's STUDENT program was shown to provide a good simulation of the behavior of some subjects solving simple algebra problems, but not of other subjects who made more use of semantic information (Paige and Simon, 1966). Computer programs have become more sophisticated exploring such mental activity as the role of verbal learning (EPAM), and the role of production in semantically rich domains such as medical diagnosis in the INTERNIST program (Simon, 1979). Progress continues in extending the problem solving theory to ill-structured problems, to explaining how people understand language,
and to understanding how the problem solver draws information from long
term memory (Simon, 1977).

Followers of the Newell and Simon school view the problem as
the important element in the problem solving process; where thoughts and
actions of the problem solver emanate from the problem itself. The
McKeeney-Keen approach puts the emphasis on the problem solver. The
underlying premise is that individuals are confronted with much incom-
ing data and that in an effort to reduce "cognitive strain" the individ-
ual develops strategies of thinking (Bruner, Olver and Greenfeld, 1966;
Miller, 1956). Bourne, Dominowski and Loftus (1979) enlarge on this
premise:

"Problem solving like any other human activity is constrained
by the nature of the system.

1. Attention to environmental information is limited
   and selective
2. Performance on a task is a joint function of the
   quality of data available and the allocation of
   processing resources....
3. Processing resources are required to maintain
   content in short term memory. Maintaining content
   in short term memory and operating on that content
   compete for the limited resources available "
   (p.236).

The individual's limitation in the speed, storage and reliability of
information processing capacities are surmounted by the use of strate-
gies. These strategies are learned with time and experience and
eventually result in habitual ways of functioning or cognitive styles.

Cognitive styles are eclectic, all encompassing descriptors,
covering a wide range of behaviors. They include field dependence,
tolerance for ambiguity, conceptual differentiation and/or integration,
degree of risk taking and locus of control (Messick, 1976; Goldstein and Blackman, 1978; Even, 1978). What all cognitive styles have in common is that they represent consistencies in the manner and form of cognition, as distinct from the content of cognition, and are conceptualized as stable attitudes or habitual patterns of behavior over time.

Unlike most cognitive styles that are bipolar, the McKenney-Keen information processing model has two dimensions with four poles (Keen, 1973). The information gathering dimension is concerned with attending, perceiving, encoding and storing information, and is composed of a preceptive and receptive pole. Information evaluation refers to strategies, plans, and operations on information and contains a systematic and intuitive pole (Nelson, 1974). The information processing style identifies the extent to which a subject functions along each of the two dimensions. An individual is described as being preceptive-systematic (PS), preceptive-intuitive (PI), receptive-systematic (RS), or receptive-intuitive (RI). Figure 5 illustrates the pattern of an individual with a preceptive-intuitive information processing style.

Information Gathering

```
                  PRECEPTIVE
                  /  \
                 /    \
                 |    PI
               _______
              |     |
             Information Evaluation
             |    |
            SYSTEMATIC
            |    |
            | INTUITIVE
            |
            RECEPTIVE
```

Figure 5. Information Processing Style Map
Behavior at each end of the two dimensions can be described in terms of specific behaviors. The preceptive information gatherer looks for cues in a set of data, focuses on a pattern or patterns and goes from one bit of data to another building a set of explanatory precepts. The receptive information gatherer tends to suspend judgment and avoid preconceptions when looking at data, is attentive to detail and to the exact implications of a piece of data, and insists on complete examination of a set of data before deriving conclusions. An analogy can be made with the selective perception process of Broadbent (1971). The pigeonholer, like the receptive thinker determines the meaning of information by an inductive process, suspending judgment and interpretation until the data are collected. The categorizer, like the preceptive thinker, starts with rules and categories and proceeds deductively to derive meaning from the incoming data. The receptive thinker is more accurate in acquiring data, but can only deal with limited amounts of information. The preceptive thinker has the advantage of handling larger amounts of information, but may miss new ideas or the uniqueness of types of information.

The information evaluation dimension is concerned with retrieval of information from long and short term memory and the manipulation of information to solve problems. The systematic thinker looks for a method and makes a plan for solving a problem, is very conscious of the approach used, defines the specific constraints of the problem early in the process, conducts an ordered search for additional information, and completes any discrete step in the solution before accepting or rejecting the approach. Intuitive thinkers tend to define and redefine
the problem while at the same time considering and/or rejecting a number of options and alternatives to problem solution. They may rely on "hunches" or unverbalized cues and describe their activity in terms of possible "fit" between problem statement and solution. Several investigators have demonstrated that a systematic plan can be efficient in problem solving (Miller, Galanter, and Pribram, 1960; Simon, 1972). However, intuitive thinking can be extremely useful in those problems in which methods to achieve solution are not obvious (Johnson, 1972).

Using ideas from McKenney's (1973) problem taxonomy, Keen (1973) hypothesized that each type of problem made different demands on the cognitive system so that:

1. PS thinkers would prefer and be more efficient at solving intelligence and search type problems
2. RS thinkers would prefer and be more efficient at solving planning type problems
3. RI thinkers would prefer and be more efficient at solving invention type problems
4. PI thinkers would prefer and be more efficient at solving research type problems.

In addition, it was believed that individuals would use their preferred thinking style regardless of the type of problems they were solving.

From a factor analysis of eleven cognitive ability tests, Keen selected seven tests to be used for placing 107 study subjects on a P, R, S, I scale. Of this group twenty subjects with identifiable thinking modes and styles (PI = 6, RI = 1, RS = 5, I = 4, S = 3, R = 1) volunteered to participate in an individual problem solving session in
which they chose five of sixteen problems to solve. There were no sub-
jects in the PS or P category, a fact attributed to the inability of
the tests to adequately discriminate preceptive type behaviors and the
homogeneity of the population in age and career interests.

Keen (1973) found that systematic thinkers chose planning type
problems as predicted, but intuitive thinkers did not choose research
type questions more often than predicted. However, intuitive thinkers
preferred problems that involved substantial conceptualization and need
for rapid hypothesis testing, chose verbal over written response as
predicted and tended to shift from one approach to another in solving
problems. Systematic thinkers did tend to be deliberate and sequential
in their thought, and use the systematic thinking mode in solving prob-
lems. Despite the inability of the researcher to do the research as
planned, he felt that the experiments strongly suggest that the infor-
mation processing model constitutes a powerful organizing framework for
describing human behavior.

There has been much theorizing but little research using the
McKenney-Keen model (Even, 1978; Nelson, 1974). Hinton (1980) used the
information processing style along with three other styles in a study
to determine their relationship with mathematics achievement, aptitude
for mathematics and attitude toward that subject. Cognitive ability
tests were used to measure the amount of functioning on each of the
four poles. As measured by Hinton, the ends of each dimension were
found not to be bipolar with S and I significantly correlated at .352
and P and R significantly correlated at .364. However, the information
gathering dimension and information evaluation dimension were not
significantly correlated. Consequently each pole was examined separately in terms of the dependent variables. S and I were found to be significantly related to achievement and aptitude for mathematics.

In the opinion of this investigator, the major weakness in both the Keen and Hinton studies were the measurement tools. As noted earlier, abilities differ from cognitive styles, yet in both studies ability tests were used, raising questions about content validity. On the basis of previous research findings, a new measurement tool was developed for this research and will be described in the following chapter. In addition, the investigation will explore the performance of subjects on each of the poles as well as on information processing style.

Effect of Demographic Variables on Abilities and Problem Solving

Though the primary focus of this study is the relationship of abilities to problem solving strategy, research on adults with a wide age range raises the question of the effect of aging on abilities and problem solving. Methodological problems persist in this area of study raising questions about the implications of sampling, cross-sectional versus longitudinal approaches and data analysis (Horn and Donaldson, 1976; Botwinick, 1977). Despite these problems, much research points to the fact that some decline in abilities does occur in the aging individual, but it may be less and slower than previously believed (Botwinick, 1977; Schaie, 1974). Indeed, it has been suggested that intellectual decline, when it does occur, is a precursor to death (Jarvik, Eisdorfer, and Blume, 1973; Riegel and Riegel, 1972). However, this finding has been obtained from retrospective research and needs confirmation in prospective studies.
Several authors have proposed that abilities showing the least
decline with age, and are likely to improve with learning are those
identified with crystallized intelligence (Gc); while those abilities
associated with fluid intelligence (Gf) are more likely to decline more
rapidly with age (Horn and Cattell, 1967; Cattell, 1971; Nesselroade,
Schaie, and Baltes, 1974; Horn, 1976). Crystallized intelligence is
described by Horn (1976) as

"awareness of concepts and terms pertaining to a broad variety
of topics as measured in general information and vocabulary
tests, while Gf is facility in reasoning, particularly in
figural and non-word symbolic materials" (p. 445).

Studies done by Schaie, Labouvie and Buech (1973) and Schaie and
Labouvie-Vief (1974) have borne this out. Briefly their findings
follow:

1. Verbal fluency (Gc)—There was little or no change in
   performance on verbal fluency tasks with increase in
   age.
2. Verbal memory (Gc)—There was a notable rise until the
   50's and slow decline after the middle to late 50's.
3. Number facility (Gc)—There is no notable decline until
   late adulthood (60) or beyond.
4. Spatial ability (Gf)—There is improvement through the
   30's and 40's and a consistent decline thereafter.
5. Inductive reasoning (Gf)—There is improvement to the
   30's and 40's and a gradual decline thereafter.
6. Rigidity–Fluency (Gf)—There is improvement through the
   30's, plateau through the 40's and a decline there-
   after.

There is good reason to believe that intellectual abilities
would decrease with age. Neuronal loss is known to occur, particularly
in the superior frontal gyrus of the frontal cortex of the brain and
progresses to all cortical layers after the fifth decade (Bondoreff, 1977). With the inability of brain cells to regenerate lost tissue in the "thinking" part of the brain, there is at least some physiological basis for intellectual changes. Horn (1978) points out that this is not the full explanation. Rigidities occur when knowledge systems become more differentiated so that the ability to shift to new knowledge systems is hampered. In addition, as knowledge systems become larger, access to information becomes more difficult. Botwinick (1977) has noted behavioral qualities which add to the older persons inability to use the capacities that exist--increase in distractability, acceptance of inconsistent solutions and unwillingness to participate in meaningless activity.

Memory, which is implicated in all cognitive activities, is also affected. Craik (1977) has demonstrated that age differences in primary, or short term memory activities are minimal, if stimuli are fully perceived, no reorganization is required and attention is not diverted. Studies indicate that retrieval of information from secondary or long term memory is the greater problem in older individuals (Arenberg and Robertson, 1977; Craik, 1977). Indications are that inadequate encoding and storage, interference from concurrent and prior events, inefficient search processes and overarousal to pressures to respond are all factors contributing to poorer long term memory functioning.

Studies examining the effects of age on problem solving activity have revealed some interesting findings. Clay (1956), using numerical problems where subjects were required to arrange numbered counters in rows and columns within a matrix to equal marginal totals, found, that
as age increased, accuracy could be maintained, but only at the cost of
time. Subjects over seventy were not able to maintain the level of ac-
curacy, even when they took longer. The investigator concluded that
older people find such perceptual organization more difficult than the
younger group. Wetherick (1964), using switching problems, studied the
difference between young, middle aged and old subjects, matched for non-
verbal intellectual ability, in problem solving. He found that there
was no difference in performance between older intelligent subjects and
younger intelligent subjects; and that it was impossible to detect
strategy differences among the groups. In examining a number of vari-
ables (age, sex, education, occupation, and nonverbal intelligence) with
performance on problem solving tasks, Kesler, Denney, and Whitely (1976)
have also concluded that non-verbal intelligence is the best predictor
of problem solving ability for both the middle and older age group. The
explanation for this, is that non-verbal intelligence tests (Block
design and Picture Completion subtests of WAIS) and problem solving
tasks measure the ability to use efficient strategies.

Rabbitt (1977) in his review, describes a number of studies that
demonstrate that the older the subject the more difficult it is to or-
organize and integrate information, to deduce classification rules, to
collect the use of previous effective and ineffective strategies and to
attempt potentially risky outcomes. Results can be mitigated by selec-
tion of materials to be committed to memory and the type of decision
making. Adaptive measures taken by subjects who recognize their percep-
tual and memory limitations has also been studied. In a study of pro-
fessional subjects, Birren (1969) found that older subjects were more
likely to take advice, focus on critical tasks, conserve and exploit their intellectual resources so as to perform as well as younger subjects in a variety of problems.

Educational level has been found to be an important factor in the maintenance of intellectual abilities. Green (1969) compared WAIS Performance subtest scores between different age groups (25 to 64 years), after matching them on the basis of education level. He found that the high-educational group had a small but significant rise with age on the six verbal tests, but no significant rise on performance tests. Higher educational groups had smaller losses with increasing age on all tests. Earlier Birren and Morrison (1961), having factor analyzed WAIS data on subjects ranging in age to 64 years, extracted a large general intellectual component accounting for approximately half of all test score variance. None of the other factors accounted for more than 11%. Age was not an important contribution to the general intelligence factor. Educational level however, contributed as much as any one subtest.

Kesler, Denney and Whiteley (1976), in addition to finding the nonverbal intelligence factor important in predicting problem solving performance, also found that educational level was a significant predictor. Occupation was another variable included in this study. The Hollingshead and Redlich occupational scale was used to rate subjects on a seven point scale. In a multiple regression analysis, they found that when the effects for education were removed, occupation was not a significant predictor of problem solving ability.
Summary

Intellectual capacities are so varied and so complex and inter-related that there is still no general consensus on how to categorize or study them. The Guilford (1967) Structure of Intellect Model was an ambitious undertaking which made researchers aware of the multiple facets of intellect to be considered. Cattell (1971), Diamond and Royce (1980) and others have proposed a hierarchical structure to explain and describe levels of mental functioning. Research continues on all models at this time. The Diamond and Royce cognition system model was used in this research as a basis for the choice of abilities. The selected tests (verbal comprehension, inductive reasoning, visualization, associative memory, ideational fluency and originality) sample a wide range of cognitive abilities which have been identified as crucial in problem solving. In this research the relationship of performance in selected tests to problem solving performance will be examined.

Whereas cognitive ability scores are static measurements of capabilities at a given point in time, strategy and cognitive style findings indicate the dynamic thought processes used by subjects. The McKenney-Keen Model proposes that individuals habitually gather and manipulate information in specific ways. This two dimension, four pole model will be examined in this study in relationship to cognitive abilities, demographic variables and problem solving performance.

To a large extent, developmental psychologists have focused their attention on the effect of the aging process on intellectual abilities and problem solving. Generally, abilities associated with fluid intelligence (reasoning and spatiovisual abilities) show a larger
decrement than those associated with crystallized intelligence (verbal comprehension and number concepts). Individual differences persist into old age with more intelligent subjects maintaining ability levels longer and exhibiting less decrease in levels of functioning with increasing age. Studies of the effect of educational level on abilities suggest the same trends as those for age and abilities. Memory deficits (particularly long term memory) exert a pervasive influence on problem solving activity as one ages. Increasing difficulty in encoding, recall, and retrieval of information results in slower reaction time, poorer heuristic strategies and fewer solution alternatives. In this study the relationship of age, educational level, years of experience and the subject taught by the nurse educator to specified abilities and problem solving performance will be examined.
CHAPTER III
RESEARCH DESIGN AND PROCEDURES

The research design and procedures chapter begins with a research model depicting the interrelationships of the four groups of variables to be investigated—cognitive ability, demographic, problem solving performance and information processing variables. The presentation of the research questions emanating from the model is followed by a description of the population and sample, methods of data collection and instrumentation used. Analysis of the data will be briefly described for each of the null hypotheses posited for the study.

Research Model

The body of cognitive ability literature has numerous studies examining relationships of cognitive abilities to each other and to task and age variables. Because of the long history of research in this area there is beginning to emerge a better understanding of the differentiation of abilities and methods for measurement. The same cannot be said about the cognitive style and problem solving literature. The voluminous literature in both areas abounds with theories and research. The state of the art is such that some aspects, such as the field articulation cognitive style and problem solving phases, have been well documented and accepted by the research community. However, much
of the theory remains untested and research results have often raised more questions, than they've answered. The McKenney-Keen information processing style fits into this uncertain category. The research, therefore will attempt to add to the information of the relationship between selected cognitive ability variables, demographic variables, information processing variables and problem solving performance. Figure 6 is the research model depicting those relationships.

**Questions for Investigation**

From the review of the literature and development of the research model the purpose evolved to explore the correlative, predictive and differential nature of individual difference variables as they relate to each other and to problem solving performance. More specifically, variables in four categories (cognitive abilities, demographic variables, information processing and problem solving performance) were examined in relationship to each other. Investigative efforts focused on providing insight into three major questions.

1) Is there a significant correlational relationship between subject's performance on selected cognitive ability tests, specified demographic variables, information processing modes and problem solving performance?

2) Do high and low performers on cognitive ability tests differ in the way they process information?
Figure 6. Research model showing relationship of variables to be explored.
3) How do successful and unsuccessful problem solvers differ in terms of (a) cognitive abilities, (b) demographic variables, and (c) information processing style?

Instrumentation

To provide information necessary to answer the investigative questions four types of instruments were used: cognitive ability tests, faculty questionnaire, problem sheet and an information processing questionnaire. Each will be discussed separately.

The measurement of cognitive abilities was accomplished with the use of six cognitive factor tests. All tests are marker tests from the Kit of Factor Referenced Cognitive Tests and are considered suitable for persons who have reached the ninth grade or more (Ekstrom et al., 1976). Because of the length of time required for all data collection only part one of the tests was used. According to Ekstrom et al. (1976), this is acceptable when the researcher wishes to shorten testing time. The order of the presentation of tests differed each time data collection was done so as to eliminate the possibility that test order affected the outcome of scores.

Each test has a face sheet which describes the test and gives the subject an opportunity to practice a sample item, before proceeding with the timed test. Examples of test description and sample items for all tests appear in Appendix A. The test descriptions were self-explanatory so that no additional discussion by the investigator was necessary. If subjects finished a test before the designated time period,
they were asked to wait before proceeding to the next test. Tests that were used, factor to be measured and length of time required for each appear below, followed by a brief description of each instrument together with psychometric properties.

<table>
<thead>
<tr>
<th>Cognitive Factor</th>
<th>Cognitive Ability Test</th>
<th>Acronym</th>
<th>Time (in minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual-Verbal</td>
<td>Extended Range Vocabulary</td>
<td>ERV</td>
<td>6</td>
</tr>
<tr>
<td>Conceptual-Reasoning</td>
<td>Letter Sets</td>
<td>LS</td>
<td>7</td>
</tr>
<tr>
<td>Perceptual-Spatiovisual</td>
<td>Paper Folding</td>
<td>PR</td>
<td>3</td>
</tr>
<tr>
<td>Perceptual-Memorization</td>
<td>Calendar</td>
<td>CT</td>
<td>7</td>
</tr>
<tr>
<td>Symbolizing-Fluency</td>
<td>Symbols</td>
<td>ST</td>
<td>5</td>
</tr>
<tr>
<td>Symbolizing-Originality</td>
<td>Different Uses</td>
<td>DU</td>
<td>5</td>
</tr>
</tbody>
</table>

**Total test time** 33 min.

**Extended Range Vocabulary Test (ERV)**—This verbal factor test contains 24 multiple choice items. The score is the total number correct, minus .25 for each incorrect answer. Criterion referenced validity is well established for this factor and reliabilities from several studies reported by Ekstrom et al. (1976, p. 15) range from .74 to .89. Interval consistency (KR-21) for the test in this study is .66.

**Letter Sets Test (LS)**—In this test sets of four letters are presented. The task is to find the rule which is suggested by four of the sets crossing out the one that does not conform to the rule. The two step process of concept formation and hypothesis testing is dependent on a successful search of long term memory. The score is the total number correct, minus .25 for incorrect answers. This inductive reasoning test has been called by several names, and its validity has been established in several studies (Ekstrom et al., 1979, pp. 20-22).
Reliabilities in several studies reported by Ekstrom et al., 1976, p. 12) range from .74 to .84. KR-21 reliability reported for this study is .66.

**Paper Folding Test (PF)**—The paper folding test requires the subject to visualize how a folded piece of paper that has a hole punched in it will look after it is unfolded. The test has ten multiple choice items to be completed in three minutes. The score on the test is the number of items marked correctly minus a fraction (.25) for those marked incorrectly. Ekstrom (1976, p. 15) reports reliabilities, for adults in two studies, of .75 to .84. Reliabilities (KR-21) reported for this test population are .46. Criterion related validity has been established for the visualization factor in three factor analytic studies (Ekstrom, 1979).

**Calendar Test (CT)**—The calendar test is one which requires that the subject follow a set of directions to arrive at an answer. A person's score is the number correct minus one-fourth the number for incorrect answered. In recent research using a matrix sampling design to study the intercorrelations of thirty-three tests taken by naval recruits, Calendar test was correlated with other integrative process tests—Following Directions (.54) and Language Rules (.53). High correlations were also found with numerical operations tests (.53 to .68) and a general reasoning test (.75) (Ekstrom et al., 1979, p. 69). Internal consistency measures (KR-21) reported for the Calendar test in this study was .39.
Symbols Test (ST)—In this figural fluency test five words are given as stimuli and the subject is asked to represent the word with as many as five different symbols. A five minute time period is provided for this test. Intercorrelations of the symbol test with thirty-two other tests show the highest correlation (.39) with other fluency tests—Ornamentation and Elaboration test (Ekstrom et al., 1979, p. 69). In this study, reliability (KR-21) is reported as .54. Because of the judgment required in determining scores, two judges were used to score the tests. Interrater reliability was found to be .99.

Different Uses Test (DU)—The different uses test is one in which the subject is presented with five objects and is asked to supply as many as five different and unique uses for that object. The subject has five minutes to complete the task. In a factor analytic study of twenty-three tests studying the relationships between divergent production factors, originality was found to be a combination of expression fluency and object flexibility (Ekstrom et al., 1979, pp. 57-60). DU was found to be correlated (.47) with semantic flexibility tests and (.53) with another originality test. Reliability measure (K.R-21) reported for DU test in this study is .67. Again because of the judgment required in scoring the tests, two judges were used. Inter-rater reliability between the two judges was found to be .99.

The faculty questionnaire was designed to obtain biographical information about the subjects in the study (See Appendix B). The information includes date of birth, highest earned credential, years of teaching experience in a school of nursing and the subject or subjects
currently taught by the subject. The purpose for collecting these data was to compare subjects in the two schools used in the study and to compare, where possible, the sample population with national and regional populations. In addition, the information was used to provide the answers posed in the research.

Subjects will be asked to solve the nine square problem (See Appendix C). It is a problem in which the subject places a number (1-9 used only once) in each square so that the total of the three numbers in each horizontal, vertical or diagonal row will total fifteen. Prior to performing this task, the investigator will give the subjects verbal instructions for both the problem and problem questionnaire (See Appendix C). The problem task is repeated at the top of the problem sheet and can be referred to during the problem solving activity. The subject is asked to show his problem solving efforts on the sheet beginning in the upper left quadrant marked I. After a period of four minutes, the subject will be asked to work in quadrant II. From 8-12 minutes work is shown in quadrant III and 12-15 minutes in quadrant IV. At the time the problem is solved the subject is to note the letter or letters appearing on the card held by the investigator and is to put that information in the small box appearing to the right of the solution. Letters were randomly selected to represent half-minute intervals, and were necessary to provide the investigator with the length of time to completion of the problem. The subject, then, puts the solution to the problem in the space provided at the top of the page. The time to complete the problem was variable, but a maximum of fifteen minutes was provided.
for this task. Those who had not reached a solution in fifteen minutes were considered unsuccessful problem solvers.

After solving the problem or after the fifteen minute problem solving effort, subjects were asked to answer the problem questionnaire. The forced choice type questionnaire was such that in each question the subject selected the description which was most descriptive of his behavior in solving the problem. Each question placed the subject in a P or R scale or an S or I scale. By doing this a profile of each subject could be obtained and an information processing style could be delineated. An example follows. Subject x answered the questionnaire in such a way as to give him the following scores: P = 4, R = 1, S = 2, I = 3. With a score of three or more in the P and I thinking mode, this person would be considered as having a preceptive-intuitive information processing style. The process can be visualized in Figure 7.

![Figure 7. Example of measurement of information processing mode and style](image-url)
Prior to the use of the problem and questionnaire in the study, a pilot study was done using nineteen graduate students in an adult education course at The Ohio State University. The purpose of the pilot study was to evaluate the:

1) adequacy of problem instructions
2) timing intervals used in determining problem solution
3) length of time given for problem solution
4) length of time for consideration of problem success or failure
5) wording of the questionnaire

Of the nineteen pilot study subjects ten (52.6%) successfully completed the problem with a median time for completion of nine and a half minutes. The range of time for completion was 7 minutes and 15 seconds to 13 minutes and 15 seconds. Timing was done in fifteen second intervals but the spread of scores indicated that half minute intervals would be adequate to describe completion time. Those who did not solve the problem in the first ten minutes appeared to have increased anxiety as the time cards, changed by the investigator, indicated a longer time span. This was another reason for increasing the timing from 15 second to 30 second intervals. In addition, it was felt that the use of letters to indicate time would reduce the level of anxiety in problem solvers. An examination of the problem solving efforts of unsuccessful subjects revealed that not one of them was close to solution, and it was felt that offering more time for solution would not result in much more success. Two of the subjects later stated that after 10 minutes of trying to solve the problem they just "gave up."
On this basis it was decided that fifteen minutes was a reasonable time to offer for problem solution.

After the problem solving and questionnaire activity, suggestions and ideas were solicited from the subjects. Several suggestions were made to improve the clarity of instructions and the wording of the questionnaire and these were incorporated in revisions for the main study. It was also discovered that two of the successful problem solvers had encountered similar problems in the past while none of the unsuccessful problem solvers had previous experience with tasks similar to the nine square problem. This factor would be included in the main study.

Population and Sample

The population consisted of nurse educators in baccalaureate and higher degree programs. Baccalaureate and higher degree programs are one type of program educating nurses for practice; the others are associate degree and diploma programs. The American Nurses' Association in 1965 recommended that minimal preparation for professional nurses be accomplished in institutions of higher learning and that preparation for technical nursing practice be done in associate degree programs. The National League of Nursing (N.L.N.) which accredits education programs and conducts biennial surveys of all nursing education programs, reports that in 1980 of the 25,020 full and part-time nurse faculty in all programs 46.5% are employed in baccalaureate and higher degree programs, 31.5% in associate degree programs and 22% in diploma programs. (N.L.N, 1981, p. 107). Of the 470 baccalaureate and higher degree programs in the United States and territories there are 14 in Ohio.
Statistics for all demographic variables used in this study are unavailable. However, national and state statistics were obtained for highest earned credentials for nursing faculties. These statistics appear in Table 1.

Two collegiate schools of nursing were used in the study—The Ohio State University (OSU) and Kent State University (K.S.U.). Both are state institutions offering undergraduate and graduate programs in many disciplines. OSU is located in the central part of Ohio while K.S.U. is located in the northeast part of the state. In both accredited nursing schools, students enter at the sophomore level and receive baccalaureate degrees at the completion of the senior year. Both nursing schools have a masters' degree program in nursing but no doctoral program.

The sample population consists of thirty-seven subjects from OSU and seventeen subjects from K.S.U. which constitutes 57.8% and 32.7% of the faculty, respectively. A comparison of total faculty and sample faculty on highest earned credentials appears in Table 2.

Subjects were asked to state the number of years of teaching experience in any school of nursing as of June 1981. Statistics appear in Table 3.

The range of years of teaching experience was 1-27 years for the OSU sample population and 1-24 years for the K.S.U. sample. Here it is interesting to note the wide range of experience in both sample populations. A majority of the OSU sample population have five years or less experience, while almost half of the K.S.U. sample have 6-10 years of experience.
Table 1

Highest Earned Credentials for Full and Part-time Faculty in Collegiate Schools of Nursing—January 1980*

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Doctorate</th>
<th>Masters</th>
<th>Baccalaureate</th>
<th>Diploma</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>U.S. and Territories</td>
<td>11,639</td>
<td>1,374</td>
<td>11.81</td>
<td>9,352</td>
<td>80.35</td>
</tr>
<tr>
<td>Midwest</td>
<td>3,390</td>
<td>361</td>
<td>10.65</td>
<td>2,657</td>
<td>78.38</td>
</tr>
<tr>
<td>Ohio</td>
<td>495</td>
<td>63</td>
<td>12.73</td>
<td>396</td>
<td>80.80</td>
</tr>
</tbody>
</table>

For Midwest and Ohio—Personal communication—Dr. John Vaughn, Chief of Research Div., National League of Nursing, New York, New York.

Midwest includes: Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, North Dakota, Ohio, South Dakota and Wisconsin.

Table 2

Total Faculty and Sample Population by Highest Earned Credentials (Full and Part-time)*

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Doctorate</th>
<th>Masters</th>
<th>Baccalaureate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
</tr>
<tr>
<td>K.S.U. Total Faculty</td>
<td>52</td>
<td>6</td>
<td>11.54</td>
<td>42</td>
</tr>
<tr>
<td>O.S.U. Total Faculty</td>
<td>61</td>
<td>13</td>
<td>21.31</td>
<td>43</td>
</tr>
<tr>
<td>K.S.U. Sample Population</td>
<td>17</td>
<td>2</td>
<td>11.76</td>
<td>14</td>
</tr>
<tr>
<td>O.S.U. Sample Population</td>
<td>37</td>
<td>3</td>
<td>8.11</td>
<td>29</td>
</tr>
<tr>
<td>Total Sample</td>
<td>54</td>
<td>5</td>
<td>9.26</td>
<td>43</td>
</tr>
</tbody>
</table>

*Source: O.S.U. Faculty statistics obtained from Dr. Edna Fritz, Director of O.S.U. School of Nursing.

K.S.U. Faculty statistics obtained from Dr. Linnea Henderson, Dean of K.S.U. School of Nursing.
Table 3
Comparison of Years of Teaching Experience for Sample Populations

<table>
<thead>
<tr>
<th>Years of Teaching Experience</th>
<th>O.S.U.</th>
<th>K.S.U.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>0-5</td>
<td>22</td>
<td>59.46</td>
</tr>
<tr>
<td>6-10</td>
<td>7</td>
<td>18.92</td>
</tr>
<tr>
<td>11-15</td>
<td>5</td>
<td>13.51</td>
</tr>
<tr>
<td>16-20</td>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td>21-25</td>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td>26-30</td>
<td>1</td>
<td>2.7</td>
</tr>
</tbody>
</table>

A comparison of age differences in the two sample populations appears in Table 4. Once again a wide range in age is noted in both populations with the O.S.U. sample population ranging from 26-65 and K.S.U. sample ranging from 30-67.

Not atypical, is the fact that most faculty in the sample population (44.44%) were involved in teaching aspects of the Medical-Surgical nursing component of the curriculum (see Table 5). This segment includes wellness concepts, basic nursing skills, care of patients with acute and chronic medical problems and care of patients requiring surgical procedures. The maternal-child health component includes obstetrical nursing care, pediatric nursing care and concepts of growth and development. In community nursing courses, care of clients in all settings outside the hospital as well as effects of culture, population
Table 4
Comparison of Age Differences in the Sample Population

<table>
<thead>
<tr>
<th>Age</th>
<th>O.S.U.</th>
<th>K.S.U.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>26-30</td>
<td>8</td>
<td>21.62</td>
</tr>
<tr>
<td>31-35</td>
<td>7</td>
<td>18.92</td>
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<tr>
<td>36-40</td>
<td>11</td>
<td>29.73</td>
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<tr>
<td>41-45</td>
<td>4</td>
<td>10.81</td>
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<tr>
<td>46-50</td>
<td>2</td>
<td>5.41</td>
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<tr>
<td>51-55</td>
<td>3</td>
<td>8.11</td>
</tr>
<tr>
<td>56-60</td>
<td>1</td>
<td>2.70</td>
</tr>
<tr>
<td>over 60</td>
<td>1</td>
<td>2.70</td>
</tr>
</tbody>
</table>

Table 5
Comparison of Subject Taught by Faculty in Sample Population

<table>
<thead>
<tr>
<th>Subject</th>
<th>O.S.U.</th>
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trends and health care delivery systems on health care are included. Mental health nursing includes primarily the care of the patient with psychiatric problems. Administration includes principles of nursing leadership and historical trends and issues in nursing. There is no representation of the community and mental health segment in the Kent State population.

**Data Collection**

All data were collected in group sessions during April 1981. Initial contact was made with the directors of The Ohio State University and Kent State schools of nursing requesting that permission be granted for the investigator to solicit participation of department faculty members in the study. A summary of the research was included with the request (See Appendix B). Upon agreement, a faculty member from each school was designated as liaison to assist the investigator in determining appropriate times and places for data collection. Data were collected at four different times in each school, one morning and one afternoon session on two different days. Times were scheduled so that the greatest numbers of faculty would be available for participation. Every full and part-time faculty member received a letter describing the research, length of time for participation and times and places for data collection (See Appendix B).

At the data collecting sessions a brief description of the research and tasks to be accomplished was repeated. Subjects were asked to sign participation consent forms which were collected separately (See Appendix B). Anonymity during data collection and data analysis
was assured. An identifying number was placed on the outside of the envelope containing all the data collection instruments; and this number was used to identify information for individual subjects. All data were collected from the subject in a single session lasting about one and a half hours. To assure that data collected at later sessions would not be contaminated because of previous knowledge, subjects at all sessions were asked not to divulge information about the tests, problem or problem questionnaire.

Analysis of Data

With the research intent being to explore the correlative, predictive and differential nature of selected variables, a brief overview of the analyses to be performed is presented below under each hypothesis. **Hypothesis 1:** None of the following variables will exhibit first order correlations with any of the others in a significant manner.

The subjects' position on each of the cognitive factors:

(a) verbal factor as measured by the Extended Range Vocabulary Test
(b) reasoning factor as measured by the Letter Sets Test
(c) spatio-visual factor as measured by the Paper Folding Test
(d) associative memory factor as measured by the Calendar Test
(e) fluency factor as measured by the Symbols Test
(f) originality factor as measured by the Different Uses Test

and the subjects'

(g) chronological age
(h) years of teaching experience
(i) educational level
and the subjects' responses on a questionnaire measuring the extent of the
(j) preceptive information processing mode
(k) receptive information processing mode
(l) systematic information processing mode
(m) intuitive information processing mode

Pearson product-moment correlations were computed to investigate the inter-correlational nature of the thirteen variables listed above.

**Hypothesis 2:** Performance on any of the six cognitive ability tests will not contribute significantly to the explanation or prediction of time taken by subjects to successfully solve the Nine Square Problem.

In this hypothesis the specific population of interest is the thirty-two subjects who successfully completed the problem. A multiple linear regression analysis was performed to investigate the predictive nature of test performance to length of time to complete a problem.

**Hypothesis 3:** There is no significant correlational relationship between subjects who score high and low on each cognitive ability test and the information processing mode used by these subjects.

A series of linear regression analyses was performed to examine the predictive nature of high and low performers on cognitive ability tests to the use of information processing modes used by these subjects.

**Hypothesis 4:** There is no significant difference between performance of subjects on cognitive ability tests and their

(a) success or failure to solve a problem
(b) information processing styles
(c) subject taught

To examine the overall differences between the specified groups and their performance on the six cognitive ability tests a multivariate analysis of variance was conducted. An analysis of variance followed to
determine whether significant differences existed when each of the dependent variables (cognitive test performance) was examined separately with problem success, information processing styles and subject taught. 

Hypothesis 5: There is no significant correlational relationship between the chronological age of subjects and their success or failure in solving the Nine Square Problem.

A Pearson product moment correlation and correlation ratio ($r^2$) was computed to determine the correlational and predictive nature of chronological age to success or failure in solving a problem.

Hypothesis 6: There is no significant relationship between the information processing style of subjects and their success or failure in solving the Nine Square Problem.

A chi square and Cramer's $V$ analysis was done to examine the degree and strength of relationship between information processing style exhibited by subjects and their success or failure in problem solving.

A more complete description of the data analysis with findings is reported in Chapter IV. Discussion of findings together with summary and conclusions appears in Chapter V.
CHAPTER IV

ANALYSIS OF DATA AND FINDINGS

In order to explore the relationships between cognitive abilities, demographic variables, information processing activities and problem solving performance as delineated by the hypotheses, the major considerations for analysis were the type of information sought and the attributes of the variables involved. Because of the number and complexity of the analyses each hypothesis is stated, the analysis—or analyses—are discussed, and the findings relevant to that hypothesis are presented. Further discussion of the findings, together with a summary and conclusions are reported in Chapter V.

Hypothesis 1: None of the following variables will exhibit first order correlations with any of the others in a significant manner.

The subjects' positions on each of the cognitive factors:

(a) verbal factor as measured by the Extended Range Vocabulary Test
(b) reasoning factor as measured by the Letter Sets Test
(c) spatio-visual factors as measured by the Paper Folding Test
(d) associative memory factor as measured by the Calendar Test
(e) fluency factor as measured by the Symbols Test
(f) originality factor as measured by the Different Uses Test and the subjects'
(g) chronological age
(h) years of teaching experience
(i) educational level

67
and the subjects' response on a questionnaire measuring the extent of

(j) preceptive information processing mode
(k) receptive information processing mode
(l) systematic information processing mode
(m) intuitive information processing mode

Analysis. To investigate the question concerning the intercorrelational nature of the above variables, Pearson product moment correlations were computed by use of the computer packages SPSS: PEARSON CORR (Nie et al., 1975). Thirteen variables were represented in the correlation matrix. Significance tests are reported for each coefficient (in parentheses) and are derived from the use of Student's t with N-2 degrees of freedom for the computed quantity. The formula used for the significance tests follows (Nie et al., 1975, p. 281).

\[ r = \frac{N - 2}{1 - r^2}^{1/2} \]

A two tailed test was used in the computation. The critical value, \( r = .265 (\alpha = .05, df = 52) \) will be used to examine statistically significant correlations. A listing of the ranges, means and standard deviations for variables considered in Hypothesis one appear in Table 6.

Findings. Because seventeen of the possible seventy-eight correlations were statistically significant (\( p < .05 \)), Hypothesis one was rejected. (See Table 7.) From the correlation matrix, those correlations greater than .265 are examined in three different ways: intercorrelations between tests, intercorrelations between tests and demographic variables and intercorrelations between information processing modes,
Table 6

Range, Means and Standard Deviations for Variables
in the Bivariate Correlation Analysis, \( N = 54 \)

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<tr>
<th>Variable</th>
<th>Acronym</th>
<th>Range</th>
<th>X</th>
<th>SD</th>
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<td>LS</td>
<td>2 - 14</td>
<td>10.11</td>
<td>2.92</td>
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<td>PF</td>
<td>1 - 9</td>
<td>5.57</td>
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<td>4. Calendar Test</td>
<td>CT</td>
<td>2.75 - 10</td>
<td>7.12</td>
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<td>9 - 23</td>
<td>14.17</td>
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<td>6. Different Uses Test</td>
<td>DU</td>
<td>8 - 24</td>
<td>16.56</td>
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<td>AGE</td>
<td>26 - 67</td>
<td>39.63</td>
<td>10.02</td>
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Table 7

Pearson Correlation Coefficients for Variables in Hypothesis 1 (n = 54)

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<td>(.548)</td>
<td>(.548)</td>
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</table>

Note: Level of statistical significance for a two-tailed test is in parentheses.
demographic variables and cognitive ability tests. Figure 8 depicts significant intercorrelations among the six cognitive ability test measures.

Figure 8. Significant intercorrelations among cognitive test measures.

The visuospatial (PF) measure is significantly correlated with the verbal (ERV) measure ($r = .301, p < .05$), the reasoning (LS) measure ($r = .393, p < .05$), and the associative memory (CT) measure ($r = .361, p < .05$) in a positive direction. The reasoning (LS) measure is significantly correlated with the associative memory (CT) measure ($r = .400, p < .05$) and the verbal (ERV) measure ($r = .357, p < .05$) in a positive direction. The originality (DU) measure is significantly correlated with the fluency (ST) measure ($r = .363, p < .05$) in a positive direction.

There are no surprises in the findings. According to Guilford (1967) the verbal factor, reasoning factor and visuospatial factor are
all classified as having the mental operation of cognition, so one would expect a positive relationship between the three factors. Associative memory enhances reasoning as demanded in the LS test; and is required for the retention of visuospatial orientation in the PF test. Both ST and DU require divergent mental operations so that the significant correlation between the two measures is an expected one.

Figure 9 depicts the significant intercorrelations between the cognitive ability tests measures and demographic measures.

![Diagram showing intercorrelations between cognitive ability tests and demographic measures](image-url)

Figure 9. Significant intercorrelations between cognitive ability test measures and demographic measures.

There is a positive correlation ($r = .291, p < .05$) between the verbal (ERV) measure and age, however; there is a negative correlation between age and associative memory (CT) measure ($r = -.376, p < .05$) and the reasoning (LS) measure ($r = -.390, p < .05$). These findings are
consistent with those of Schaie, Labouvie and Buech (1973) and Schaie, Labouvie-Vief (1974). The findings are also consistent with the theory that those abilities associated with crystallized intelligence do not decrease with age; while those abilities associated with fluid intelligence decline earlier and faster with age (Horn and Cattell, 1967; Cattell, 1971; Nesselroade, Schaie and Baltes, 1974; Horn, 1976). Verbal ability is considered a part of crystallized intelligence; reasoning a part of fluid intelligence. The flexibility tests ST and DU and the visuospatial test (PF), associated with fluid intelligence, are not negatively correlated in a significant manner, as would be expected. The significant negative correlation of associative memory (CT) is consistent with the findings of Craik (1977) who found that activities requiring fully perceived stimuli and reorganization decline with age. The significant negative correlation of associative memory (CT) with teaching experience (TEX) \( r = -.376, p < .05 \) can be explained on the basis that nurse educators with less teaching experience are likely to be younger, so that one would expect the same effect as that of age with CT. Age is positively correlated with educational level (ELV) \( r = .276, p < .05 \) suggesting that older nurse educators have higher degrees. Teaching experience (TEX) is negatively correlated with educational level \( r = -.381, p < .05 \) suggesting that the longer the teacher has been teaching the more likely she is to have lower educational credentials.

Figure 10 depicts intercorrelations of information processing mode with demographic variables and cognitive ability tests.
The originality measure (DU) is positively correlated with the receptive (R) measure ($r = .292, p < .05$) while negatively correlated with the preceptive (P) measure ($r = -.292, p < .05$). This suggests that subjects who score higher on the originality factor are likely to process information in discrete units; while those who score lower on the originality factor are likely to process information by categorization.

Teaching experience (TEX) is correlated positively with the preceptive (P) information gathering measure ($r = .322, p < .05$), while correlated negatively to the receptive (R) information gathering measure ($r = -.322, p < .05$). This suggests that subjects with longer teaching experience are more likely to use the categorization mode for gathering information while those with less experience are more likely to gather information in discrete units.
Hypothesis 2. Performance on any of the six cognitive ability tests will not contribute significantly to the explanation or prediction of time taken by subjects to successfully solve the Nine Square Problem.

Analysis. None of the subjects in the study had previously encountered the Nine Square Problem; so this factor was not considered in problem examination. Of the fifty-four subject in the study, thirty-two (59.26%) solved the problem successfully in the fifteen minutes provided for this task. The thirty-two successful problem solvers are the subject of inquiry in this hypothesis. A multiple linear regression was computed by use of the computer package SPSS: Regression (Nie et al., 1975). Because the independent variables are measured in different units the form of the standardized regression equation is:

\[ Y = \text{Constant} + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ldots + \beta_m X_m \]

The Pearson product moment correlation between \( Y \) and \( \hat{Y} \) (estimated value of the criterion variable \( Y \)) is \( R \) or multiple correlation coefficient. The coefficient of multiple determination or \( R^2 \) is a measure of the percent of variance in \( Y \) accounted for by the least squares combination of the dependent variable.

Test of statistical significance of the multiple correlations is done using an \( F \) test with \( K \) and \( N-K-1 \) degrees of freedom.

\[ F = \frac{R^2/K}{(1-R^2)/(N-K-1)} \]

where

\( N \) = sample size, and \( K \) = the number of independent variables. The tabled critical value for \( F \) at \( df = 7, 25, p < .05 \) is 2.49.
**Findings.** $H_0^2$ failed to be rejected as Time $R^2$ is not statistically significant ($R^2 = 0.22$, df 6, 25, $p < 1.172$). (See Table 7.)

As seen in Table 8 the amount of variation in Time that can be explained by linear dependence upon the six independent variables operating jointly is 22% ($R^2 = .22$). Of this figure over half can be accounted for by the DU variable ($R^2 = .119$). The conclusion to be drawn, then, is that performance on cognitive ability tests cannot predict which subjects will complete the problem in a shorter time, however, if any test were to be used for this purpose, the originality test (DU) would be the one of choice. Many investigators have linked the divergent and convergent abilities required in the originality test with creativity; and creativity has long been linked with improved performance in problem solving (Paige and Simon, 1966; Maier, 1969; Scandura, 1977; Ekstrom et al., 1979). From this standpoint, it is not surprising that the originality test explained most of the variance in time to solve the Nine Square Problem.

**Hypothesis 3.** There is no significant correlational relationship between subjects who score high and low on cognitive ability tests and the information processing mode used by the subjects.

**Analysis.** Again a subset of the total sample population was examined. Placement of subjects in high and low categories was determined by test scores and appears in Table 9.
### Table 8

Summary of Multiple Regression Analysis of Cognitive Ability Tests with Time for Problem Completion, N = 32

<table>
<thead>
<tr>
<th></th>
<th>Multiple R</th>
<th>R Square</th>
<th>RSQ Change</th>
<th>Simple R</th>
<th>B</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERV</td>
<td>.410</td>
<td>.169</td>
<td>.049</td>
<td>-.213</td>
<td>-.346</td>
<td>-.263</td>
</tr>
<tr>
<td>L.S.</td>
<td>.418</td>
<td>.175</td>
<td>.006</td>
<td>-.186</td>
<td>-.190</td>
<td>-.011</td>
</tr>
<tr>
<td>PF</td>
<td>.448</td>
<td>.201</td>
<td>.026</td>
<td>-.249</td>
<td>-.115</td>
<td>-.056</td>
</tr>
<tr>
<td>CT</td>
<td>.465</td>
<td>.216</td>
<td>.016</td>
<td>-.122</td>
<td>-.521</td>
<td>-.199</td>
</tr>
<tr>
<td>ST</td>
<td>.469</td>
<td>.220</td>
<td>.003</td>
<td>-.229</td>
<td>-.896</td>
<td>-.073</td>
</tr>
<tr>
<td>DU</td>
<td>.345</td>
<td>.119</td>
<td>.119</td>
<td>-.345</td>
<td>-.357</td>
<td>-.309</td>
</tr>
</tbody>
</table>

Constant 27.591

<table>
<thead>
<tr>
<th>Multiple R</th>
<th>R Square</th>
<th>Sum of Squares</th>
<th>Mean Square</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>.469</td>
<td>.220</td>
<td>128.549</td>
<td>21.425</td>
<td>1.172</td>
</tr>
</tbody>
</table>

Table 9

Placement of Subjects into High and Low Test Performance Categories

<table>
<thead>
<tr>
<th></th>
<th>High Range</th>
<th>Low Range</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>#</td>
<td></td>
</tr>
<tr>
<td>ERV</td>
<td>18.25-22.75</td>
<td>6-13.75</td>
<td>34</td>
</tr>
<tr>
<td>L.S.</td>
<td>12.50-14.00</td>
<td>2-8.50</td>
<td>33</td>
</tr>
<tr>
<td>PF</td>
<td>7-9</td>
<td>1-4.5</td>
<td>34</td>
</tr>
<tr>
<td>CT</td>
<td>7.75-10</td>
<td>2.75-6.25</td>
<td>34</td>
</tr>
<tr>
<td>ST</td>
<td>16-23</td>
<td>9-12</td>
<td>36</td>
</tr>
<tr>
<td>DU</td>
<td>19-24</td>
<td>8-14</td>
<td>33</td>
</tr>
</tbody>
</table>
The maximum number of subjects to be placed in the high or low group was eighteen or 1/3 of the subjects. In instances where subjects clustered at the end of a continuum, the number of subjects was reduced in that category. For example, in the high LS category there were five subjects who scored 12.00. Since the inclusion of these five subjects in the high LS group would bring the total of that group to 21, all subjects scoring at the 12.00 level were eliminated, bringing the total number of subjects in the high LS group to sixteen.

A series of simple regressions were computed by use of the computer package SPSS: SCATTERGRAM (Nie et al., 1975). The findings appear in Table 8. Statistical significance for regression of Y on X is accomplished by the analysis of variance F test:

\[ F = \frac{r^2(n-2)}{1-r^2} \quad \text{with df } 1, n-2, \ p < .05 \]

Findings. Null hypothesis 3, that \( p = 0 \), failed to be rejected. There were not significant regression coefficients in high or low level cognitive ability test performance groups when examined with preceptive, receptive, systematic and intuitive information processing mode measurements (see Table 10). In failing to reject the null hypothesis that no significant relationships exist between high and low level performers on cognitive ability tests and information processing modes, there is a possibility that a Type II error (accepting the null hypothesis when it should be rejected) exists.
Table 10
Summary of Linear Regression Analysis of High and Low Performers on Cognitive Ability Tests with Information Processing Modes

<table>
<thead>
<tr>
<th></th>
<th>ERV</th>
<th></th>
<th>LC</th>
<th></th>
<th>PF</th>
<th></th>
<th>CT</th>
<th></th>
<th>ST</th>
<th></th>
<th>DU</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Simple R</td>
<td>.168</td>
<td>-.152</td>
<td>-.156</td>
<td>-.277</td>
<td>-.218</td>
<td>.035</td>
<td>-.123</td>
<td>-.040</td>
<td>-.293</td>
<td>-.110</td>
<td>-.095</td>
<td>-.218</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.028</td>
<td>.023</td>
<td>.000</td>
<td>.077</td>
<td>.048</td>
<td>.001</td>
<td>.015</td>
<td>.002</td>
<td>.086</td>
<td>.012</td>
<td>.009</td>
<td>.047</td>
</tr>
<tr>
<td>Sig. (p&lt;)</td>
<td>.506</td>
<td>.573</td>
<td>.954</td>
<td>.282</td>
<td>.416</td>
<td>.890</td>
<td>.627</td>
<td>.883</td>
<td>.238</td>
<td>.665</td>
<td>.717</td>
<td>.408</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Simple R</td>
<td>-.168</td>
<td>.152</td>
<td>.156</td>
<td>.277</td>
<td>.218</td>
<td>-.035</td>
<td>.123</td>
<td>.040</td>
<td>.293</td>
<td>.110</td>
<td>.095</td>
<td>.218</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.028</td>
<td>.023</td>
<td>.000</td>
<td>.077</td>
<td>.048</td>
<td>.001</td>
<td>.015</td>
<td>.002</td>
<td>.086</td>
<td>.012</td>
<td>.009</td>
<td>.047</td>
</tr>
<tr>
<td>Sig. (p&lt;)</td>
<td>.506</td>
<td>.573</td>
<td>.954</td>
<td>.282</td>
<td>.416</td>
<td>.890</td>
<td>.627</td>
<td>.883</td>
<td>.238</td>
<td>.665</td>
<td>.717</td>
<td>.408</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Simple R</td>
<td>-.215</td>
<td>.096</td>
<td>.180</td>
<td>-.195</td>
<td>-.123</td>
<td>.121</td>
<td>.378</td>
<td>-.253</td>
<td>.005</td>
<td>.188</td>
<td>.264</td>
<td>-.453</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.046</td>
<td>.009</td>
<td>.032</td>
<td>.038</td>
<td>.015</td>
<td>.015</td>
<td>.143</td>
<td>.064</td>
<td>.000</td>
<td>.035</td>
<td>.070</td>
<td>.205</td>
</tr>
<tr>
<td>Sig. (p&lt;)</td>
<td>.391</td>
<td>.724</td>
<td>.506</td>
<td>.454</td>
<td>.651</td>
<td>.631</td>
<td>.122</td>
<td>.344</td>
<td>.983</td>
<td>.455</td>
<td>.305</td>
<td>.078</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High</td>
<td></td>
<td>Low</td>
<td>High</td>
<td></td>
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<tr>
<td>Simple R</td>
<td>-.215</td>
<td>-.096</td>
<td>-.180</td>
<td>.195</td>
<td>.123</td>
<td>.121</td>
<td>-.378</td>
<td>.253</td>
<td>-.005</td>
<td>-.188</td>
<td>-.264</td>
<td>.453</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.046</td>
<td>.009</td>
<td>.032</td>
<td>.038</td>
<td>.015</td>
<td>.015</td>
<td>.143</td>
<td>.064</td>
<td>.000</td>
<td>.035</td>
<td>.070</td>
<td>.205</td>
</tr>
<tr>
<td>Sig. (p&lt;)</td>
<td>.391</td>
<td>.724</td>
<td>.506</td>
<td>.454</td>
<td>.651</td>
<td>.631</td>
<td>.122</td>
<td>.344</td>
<td>.983</td>
<td>.455</td>
<td>.305</td>
<td>.078</td>
</tr>
</tbody>
</table>
Low DU test performance measures with systematic and intuitive measures approach significance at the $p < .078$ level. It is probable that this relationship would be significant with a larger number of subjects. If the reader refers to Table 6 where DU is not broken down into high and low categories, correlations with S and I are extremely low (.101). In dichotomizing the test variables into extreme groups a different picture has emerged, at least with the DU variable.

**Hypothesis 4.** There is no significant difference between performance of subjects on cognitive style tests and their

(a) success or failure to solve the Nine Square Problem

(b) information processing styles (preceptive-systematic, preceptive intuitive, receptive systematic, receptive intuitive)

(c) teaching responsibilities (Med-Surg. MCH, P. CH, ADM)

**Analysis.** A multivariate analysis of variance served to test each part of Hypothesis 4. The components of the dependent vector variable are the six measures of cognitive ability test performance: ERV, LS, PF, CT, ST, and DU. The groups under consideration differ in each part of the hypothesis. For the first part two groups, successful and unsuccessful problem solvers are considered. For part b four cognitive style groups are considered—preceptive systematic (PS), preceptive intuitive (PI), receptive-systematic (RS) and receptive-intuitive (RI).

The method used for placement into cognitive style groups was discussed in the previous chapter. The last part of hypothesis 4 deals with the relationship of subjects' performance on cognitive ability tests and the subject matter taught by these subjects. Teachers were placed in one of five groups according to response or the faculty questionnaire-medical-
surgical nursing (MS), maternal-child health nursing (MCH), psychiatricmental health nursing (P), and administration type courses (ADM).

An overall or multivariate test (α = .05) was conducted on the dependent variables for the three different kinds of groups using the MANOVA program (Clyde, 1969). The $F$ test, transformed from Hotellings $T^2$, is used for the multivariate test of significance (Tatsuoka, 1971, p. 78). The resulting calculated $F$ value is compared against a critical $F$ value having $df = p$ and $N-p-1$. Rejection of the null hypothesis allows one to infer $U_{j1} \neq U_{j2} \neq U_{j3} \cdots \neq U_{j6}$, for at least one of the dependent variables.

Univariate analyses of variance were run on each dependent variable separately. When univariate tests were significant post hoc comparisons by means of the Scheffé test ($α = .05$) were done to determine if significant differences existed between groups on that variable. The formula is:

$$F = \frac{s^2_{i}}{a-1 \left( \frac{1}{n_j} + \frac{1}{n_j} \right) MS(S/A)}$$

The Scheffé test was used because comparisons of interest are exclusively pairwise, and group $n$'s are unequal (Kennedy, 1977, p. 203).

**Findings.** A summary of the descriptive statistics for the three groups appears in Table 11.

The omnibus null hypothesis for each of the group analyses was not rejected (see Table 12). The conclusions that follow are that

(a) problem solvers and non-solvers appear to perform equally well on ERV, LS, CT, FF, ST, and DU cognitive ability tests.
Table 11

Summary of Descriptive Statistics for Analysis of Differences in Performance on Cognitive Ability Tests with Problem, Strategies and Subject Taught

<table>
<thead>
<tr>
<th>Problem</th>
<th>ERV</th>
<th>LS</th>
<th>PF</th>
<th>CT</th>
<th>ST</th>
<th>DU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solved</td>
<td>N</td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>32</td>
<td>16.59</td>
<td>3.30</td>
<td>10.62</td>
<td>2.42</td>
<td>5.86</td>
</tr>
<tr>
<td>Unsolved</td>
<td>N</td>
<td>22</td>
<td>15.06</td>
<td>4.39</td>
<td>9.38</td>
<td>3.46</td>
</tr>
</tbody>
</table>

| Strategies | PS | N   | 19  | 15.49 | 3.55 | 8.78 | 3.14 | 6.07 | 2.08 | 6.87 | 1.85 | 13.16 | 2.93 | 15.11 | 4.01 |
|            | PI | N   | 14  | 16.05 | 4.82 | 11.18 | 3.06 | 5.61 | 2.42 | 7.70 | 1.41 | 13.79 | 2.75 | 16.57 | 3.63 |
|            | RS | N   | 12  | 17.00 | 3.65 | 10.85 | 2.56 | 4.92 | 2.55 | 6.58 | 1.79 | 15.33 | 4.48 | 17.92 | 4.06 |
|            | RI | N   | 9   | 15.47 | 3.14 | 10.28 | 1.80 | 5.33 | 2.02 | 7.44 | 2.07 | 15.33 | 4.42 | 17.78 | 2.39 |

| Subject Taught | MS | N   | 24  | 15.58 | 3.60 | 10.84 | 2.83 | 5.56 | 2.16 | 7.23 | 1.92 | 13.50 | 3.87 | 16.04 | 4.33 |
|                | MCH | N   | 14  | 17.29 | 2.76 | 10.30 | 2.32 | 6.54 | 1.43 | 7.11 | 1.60 | 14.64 | 3.20 | 17.93 | 3.34 |
|                | P   | N   | 9   | 15.17 | 4.81 | 8.83 | 3.08 | 4.00 | 2.45 | 6.47 | 1.94 | 14.22 | 2.33 | 16.67 | 3.08 |
|                | CH  | N   | 3   | 13.08 | 4.69 | 7.08 | 4.40 | 3.67 | 2.75 | 6.83 | 1.16 | 16.67 | 5.51 | 15.00 | 4.36 |
|                | ADM | N   | 4   | 17.63 | 5.07 | 10.19 | 3.11 | 7.19 | 2.21 | 8.13 | 1.61 | 14.50 | 4.66 | 15.75 | 3.20 |
(b) subjects classified as using PS, PI, RS and RI strategies perform equally well on ERV, LS, CT, PF, ST and DU cognitive ability tests

(c) subject's teaching responsibilities, grouped as MS, MCH, P, CH and ADM, did not differ significantly on performance in ERV, LS, CT, PF, ST and DU cognitive ability tests.

Table 12

Summary of the Results of MANOVA Analysis of Cognitive Ability Test Performances with Problem Solving Performance, Strategies Used and Subject Taught*

<table>
<thead>
<tr>
<th>Source</th>
<th>df Hypothesis</th>
<th>df Error</th>
<th>F</th>
<th>p&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problem</td>
<td>6.00</td>
<td>47.00</td>
<td>1.31</td>
<td>0.27</td>
</tr>
<tr>
<td>Strategies</td>
<td>18.00</td>
<td>127.76</td>
<td>1.32</td>
<td>0.19</td>
</tr>
<tr>
<td>Subject Taught</td>
<td>24.00</td>
<td>164.71</td>
<td>1.07</td>
<td>0.38</td>
</tr>
</tbody>
</table>

*Only the first roots are reported for Strategies and Subject taught.

A univariate analysis of variance to examine components individually revealed some significant differences (see Table 13). Performance on the calendar test (CT) revealed significant differences between successful and unsuccessful problem solvers (p < .04). This would indicate that the associative memory factor is the best predictor for success in solving the Nine Square Problem. No other cognitive ability test significantly discriminates between successful and unsuccessful problem solvers.
Table 13

Summary of the Results of Univariate Analyses of Variance: Performance on Cognitive Ability Tests with Problem Solving Performance, Strategies Used, and Subject

| Source (Problem) | MS    | F (1,52) | p<  
|------------------|-------|----------|------
| ERV              | 30.80 | 2.16     | .15  |
| LS               | 20.12 | 2.42     | .13  |
| FF               | 6.60  | 1.31     | .26  |
| CT               | 13.56 | 4.60     | .04* |
| ST               | 0.009 | 0.001    | .98  |
| DU               | 20.19 | 1.41     | .24  |

| Source (Strategies) | MS    | F (3,50) | p<  
|---------------------|-------|----------|------
| ERV                 | 6.50  | 0.43     | .73  |
| LS                  | 18.89 | 2.38     | .08  |
| PF                  | 3.44  | 0.67     | .58  |
| CT                  | 3.42  | 1.09     | .36  |
| ST                  | 16.65 | 1.32     | .28  |
| DU                  | 25.21 | 1.83     | .15  |

| Source (Subject Taught) | MS    | F (4,49) | p<  
|-------------------------|-------|----------|------
| ERV                     | 17.40 | 1.21     | .30  |
| LS                      | 13.91 | 1.71     | .16  |
| PF                      | 14.14 | 3.28     | .02* |
| CT                      | 2.09  | .65      | .63  |
| ST                      | 8.27  | .63      | .65  |
| DU                      | 10.67 | .73      | .58  |

* p < .05

In examining strategy groups with performance on each cognitive ability test, results demonstrate that no cognitive ability test significantly discriminates between strategy groups (see Table 13). Performance on Letter Sets tests (LS) is approaching significance (p < .08) and
an examination of LS with strategies on Table 9 indicates that this may be occurring in the PS and PI group. One must once again entertain the possibility of a Type II error when failing to reject the hypothesis that all cognitive ability groups are equal in the strategies used to solve problems.

There are significant differences between groups of nurse educators teaching different subjects and their performance on the paper folding test (PF) \((p < .02)\) when compared with other cognitive ability tests (see Table 13). A post-hoc Scheffé test was done to examine more closely where differences were occurring and to determine if the differences were significant. A pairwise comparison of group four (those teaching community health) and group five (those teaching administration principles) were selected for examination as the greatest disparity between means was present in these two groups. If a significant result was obtained, additional comparisons would be examined. The findings of the Scheffé test revealed an \(F\) of 1.23 at \(df = 4,49\). This value did not exceed the tabled critical value of \(F = 2.55 (\alpha = .05, df = 4,49)\). The conclusion, therefore is that there are no significant differences between the subject taught and performance on the paper folding (PF) test. Additional comparisons were not done as they would also prove to be insignificant.

**Hypothesis 5:** There is no significant correlational relationship between the chronological age of subjects and their success or failure in solving the Nine Square Problem.

**Analysis.** A Pearson product-moment correlation was computed by use of the computer package SPSS: PEARSON CORR (Nie et al., 1975). In
addition a correlation ratio ($E^2$) was computed to determine a measure of association between $Y$ (interval measurement of age) and $X$ (nominal measurement of problem success or failure). The formula used to compute $E^2$ is that of Korin (1975, p. 131).

$$E^2 = \frac{\sum_{i} \sum_{j} \frac{Y_{ij}^2 - \bar{Y}^2}{\bar{Y}^2 - n\bar{Y}^2}}{\text{rows columns}}$$

$E^2$ is much like $r^2$ (coefficient of determination) in that a knowledge of $X$ gives a prediction of $Y$.

Findings. The Pearson $r$ of age with problem solution was $-.042$, $p < .761$ indicating there was little relationship which was not significant at the $\alpha .05$ level. $E^2$ was found to be $.114$ indicating that the two variables are weakly associated with only $11.4\%$ of the variance in age explaining or predicting problem performance.

Hypothesis 6: There is no significant relationship between the information processing style used by subjects and their performance in solving the Nine Square Problem.

Analysis. A one sample chi square test was performed using the computer package SPSS-CROSSTABS (Nie et al., 1975) to determine whether $H_0$: $p_1 = p_2 = p_3 = p_4$. The formula

$$\chi^2 = \sum_{i} \sum_{j} \frac{(Y_{ij} - E_{ij})^2}{E_{ij}}$$
was used where $Y_{ij}$ are the observed frequencies and $E_{ij}$ are the expected frequencies. A Cramers V statistic was computed to determine the strength of the relationship and is defined as

$$V = \left(\frac{\phi^2}{k-1}\right)^{1/2}$$

where the phi statistic is derived from $\left(\frac{X^2}{N}\right)^{1/2}$.

Findings. A 2x4 contingency table with observed frequencies appears in Table 14.

Table 14

<table>
<thead>
<tr>
<th></th>
<th>PS</th>
<th>PR</th>
<th>RS</th>
<th>RI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solvers</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Non-Solvers</td>
<td>11</td>
<td>9</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

The obtained $X^2_3 = 3.90$, which was significant at the .27 level. Since this did not exceed the tabled critical value ($X^2 = 7.815$) the null hypothesis failed to be rejected. This would indicate the absence of a relationship or statistical independence between cognitive style groups and problem performance. The value of $V$ was computed as .269, confirming the fact that the strength of the relationship is weak.

A summary of the study, conclusions, interpretation of analysis, together with recommendation for future research are presented in Chapter V.
Summary of the Study

The purpose of the study was to explore the relationship of problem solver attributes and problem solving behaviors. Specifically, the researcher sought: (1) to explore the relationships between subjects' performance on selected cognitive ability tests, demographic variables, information processing modes and problem solving performance, and (2) to examine whether high and low level performers on cognitive ability tests differ in the length of time it takes to successfully solve a problem and in the information processing modes used, and (3) to examine the difference between successful and unsuccessful problem solvers in terms of cognitive ability test performance, specified demographic variables and information processing style.

The following assessment instruments were used.

<table>
<thead>
<tr>
<th>Construct Measured</th>
<th>Assessment Instrument</th>
<th>Acronym</th>
</tr>
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<tr>
<td>Verbal Comprehension</td>
<td>Extended Range Vocabulary Test</td>
<td>ERV</td>
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<td>Inductive Reasoning</td>
<td>Letter Sets Test</td>
<td>LS</td>
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<td>Visualization</td>
<td>Paper Folding Test</td>
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<td>Integrative Process</td>
<td>Calendar Test</td>
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<td>Ideational Fluency</td>
<td>Symbols Test</td>
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<td>Originality</td>
<td>Different Uses Test</td>
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<td>Age</td>
<td>Faculty Questionnaire</td>
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<td>Educational Level</td>
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<td>Years of Teaching Experience</td>
<td>Faculty Questionnaire</td>
<td>TEX</td>
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<td>Subject Taught</td>
<td>Faculty Questionnaire</td>
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<tr>
<td>Information Processing Mode:</td>
<td>Problem Solving Questionnaire:</td>
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<td>Preceptive, Receptive, Systematic, Intuitive</td>
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<td>Preceptive-systematic, Preceptive-intuitive, Receptive-systematic, Receptive-intuitive</td>
<td>PS, PI, RS, RI</td>
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**Problem Solving Time and Solution: Nine Square Problem**

To provide insight into the questions for investigation, six testable hypotheses were formulated, a faculty questionnaire was designed, a problem was selected and a problem solving questionnaire was developed. The Nine Square Problem and problem solving questionnaire were pilot tested in winter quarter, 1981.

The population under consideration was nurse educators teaching in baccalaureate and higher degree programs. The sample population consists of 37 volunteer subjects from The Ohio State University and 17 volunteer subjects from Kent State University schools of nursing which constitutes 57.8% and 32.7% of the faculty, respectively. Comparisons of the sample population with Ohio, midwest and national populations revealed a striking similarity on the basis of highest earned educational credential. This was the only demographic variable for which statistics were available for all populations.

Data were collected in eight group sessions during April 1981. Anonymity during data collection and data analyses was assured by assigning a number to each subject; and the numbers were used to identify an individual's response on data collection instruments. The order of
cognitive tests was randomly determined for each data collecting session to eliminate possible order effects. Subjects were asked to refrain from discussion of the research until after all data were collected.

The data were analyzed using a variety of statistical techniques. They include: (1) Pearson product moment intercorrelations of thirteen variables; (2) multiple linear regression analysis with the dependent variable of time taken by successful problem solvers and independent variables of performance on six cognitive ability tests; (3) simple linear regression analysis of high and low level performers on cognitive ability tests as dependent variable with information processing mode scores of these subjects as independent variable; (4) multivariate analysis of variance with the performances on cognitive ability tests as the dependent variables and problem success, information processing style and subject taught as independent variables examined separately; (5) Pearson product moment correlation and correlation ratio of chronological age as dependent variable and problem success as independent variable and (6) chi square and Cramers V analysis of problem solving success as dependent variable and problem solving style as independent variable. Because the research is exploratory in nature and the intent is to look for general patterns and/or relationships the more liberal alpha level of .05 is used in all tests of significance.

Results of the data analysis are summarized under each hypothesis.

Hypothesis 1: None of the following variables will exhibit first order correlations with any of the others in a significant manner. The subjects' positions on each of the cognitive factors:

(a) verbal factor as measured by the Extended Range Vocabulary Test

(b) reasoning factor as measured by the Letter Sets Test
(c) spatiovisual factor as measured by the Paper Folding Test
(d) associative memory factor as measured by the Calendar Test
(e) fluency factor as measured by the Symbols Test
(f) originality factor as measured by the Different Uses Test
and the subjects'
(g) chronological age
(h) years of teaching experience
(i) educational level
and the subject's response on a questionnaire measuring the extent of

(j) preceptive information processing mode
(k) receptive information processing mode
(l) systematic information processing mode
(m) intuitive information processing mode

Significant bivariate correlations ($p < .05$) are organized under three areas: (1) correlations among cognitive test measures, (2) correlations between cognitive ability test measures and demographic measures, and correlations between information processing modes, cognitive ability test measures and demographic measures.

1. The verbal measure (ERV) correlated with both the reasoning factor (LS) and spatiovisual factor (PF). In addition to correlation with ERV, PF correlated with LS and associative memory measure (CT). The fluency measure (ST) correlated with the originality measure (DU).

2. Age was positively correlated with educational level (ELV) and ERV and negatively correlated with CT and LS. Teaching experience was negatively correlated with LS, ELV and CT.

3. The originality test measure (DU) was positively correlated with the receptive information processing measure (R) and negatively
correlated to the preceptive information processing measure (P). Teaching experience (TEX) was positively correlated to P and negatively correlated to R.

Hypothesis 2. Performance on any of the six cognitive ability tests will not contribute significantly to the explanation or prediction of time taken by subjects to successfully solve the Nine Square Problem.

The null hypothesis 2 failed to be rejected. The amount of variation in time that can be explained by linear dependence upon the six independent variables operating jointly is 22%. Of this figure over half (11.9%) can be accounted for by the originality variable.

Hypothesis 3. There is no significant correlational relationship between subjects who score high and those who score low on cognitive ability tests and the information processing mode used by subjects.

The null hypothesis 3 failed to be rejected. There were no significant regression coefficients in high or low level cognitive ability test performance groups when examined with preceptive, receptive, systematic and intuitive information processing mode measurements.

Hypothesis 4. There is no significant difference between performance of subjects on cognitive ability tests and their

(a) success or failure to solve the Nine Square Problem

(b) information processing style (preceptive-systematic, preceptive-intuitive, receptive-systematic, receptive-intuitive)

(c) teaching responsibilities (medical-surgical nursing, maternal-child health, psychiatric nursing, community health and administration principles).

The omnibus hypothesis for each of the group analyses (a, b and c) was not rejected. There were no significant differences between successful and unsuccessful problem solvers, between subjects using different information processing styles, or between subjects teaching different subjects and performance on six cognitive ability tests. A
univariate examination of each test with each group (a, b and c) revealed that the calendar test did discriminate significantly between the successful and unsuccessful problem solvers. The paper folding test discriminated between teaching responsibility groups, but this significance was not strong enough in the post hoc test to identify a group or groups responsible for contributing to that significance.

**Hypothesis 5.** There is no significant correlational relationship between the chronological age of subjects and their success or failure in solving the Nine Square Problem.

Hypothesis 5 failed to be rejected. The correlation of age with problem solving success was only minimally negatively correlated. Only 11.4% of the variance in age could explain or predict problem solving performance.

**Hypothesis 6.** There is no significant relationship between the information processing style used by subjects and their performance in solving the Nine Square Problem.

Hypothesis 6 failed to be rejected indicating that there was an insignificant relationship between the information processing style used and problem performance.

**Conclusions and Interpretations**

In Chapter I it was noted that research on teacher problem solving has focused on the decision making process in the teaching environment. However, if problem solving is an important function of teachers, not only is it necessary to know what decisions are made, but how they are made. This study, therefore, is an attempt to learn about how nurse educators think and the relationship of this thinking on problem solving. In exploring this issue, concepts from developmental and cognitive psychology and organizational behavior were utilized. The initial questions
that were posed in this research and further delineated in the hypothesis were concerned with: 1) the relationships between subjects' performance on selected cognitive ability tests, specified demographic variables, information processing activity and problem solving performance, 2) the relationship between high and low performance on cognitive ability tests and the use of information processing modes used in solving a problem, and 3) the differences between successful and unsuccessful problem solvers in terms of cognitive ability test performance, age, and information processing style of subjects.

Since the study is exploratory in nature and relies heavily on correlational techniques one should be careful not to infer causality in the relationships. In addition, extrapolation of interpretations should be confined to the variables used and the population under discussion. In this context, the following conclusions and interpretations are offered for the three investigative questions that appeared in the problem statement.

**Question 1.** Is there a relationship between subjects' performance on selected cognitive ability tests, specified demographic variables, information processing activity and problem solving performance?

Significant bivariate relationships were found between cognitive test performance and information processing modes, cognitive test performance and age, cognitive test performance and teaching experience and teaching experience and information processing modes. The originality test measure was found to be positively correlated \( (r = .292, p < .05) \) with the receptive information processing measure and negatively correlated \( (r = 0.292, p < .05) \) with the preceptive information processing mode. This suggests that those subjects who tend to do well in
generating novel ideas tend to gather information in discrete units while those who do less well in generating new ideas tend to gather information for placement into categories. There are no studies with which to compare these findings so that replication in future studies would be desirable to confirm these findings.

There was a moderate negative correlation of age with inductive reasoning ($r = -0.390, p < .05$), and age with associative memory ($r = 0.376, p < .05$). As noted earlier, the findings with associative memory and age are similar to those of Craik (1977), namely that activities requiring fully perceived stimuli and reorganization of content show a decline with age. Likewise, inductive reasoning has been found to decline with age (Horn and Cattell, 1967; Cattell, 1971; Horn, 1976). The crystallized intelligence ability measure (extended range vocabulary test) was found to be positively correlated with age ($r = 0.291, p < .05$) and has been previously confirmed in studies by Schaie, Labouvie and Buech (1973) and Schaie and Labouvie-Vief (1974).

Nurse educator subjects with less teaching experience tend to have better performance scores on the inductive reasoning test ($r = -0.376, p < .05$) and the associative memory test ($r = -0.376, p < .05$). The initial conclusion would be that less teaching experience is equated with lower age and this would account for the higher performance in the reasoning and associative memory tests. However, in this sample population there was no relationship with age and teaching experience (see Table 7) so this could not account for the findings. Perhaps, a possible explanation can be found in the fact that in this study, longer teaching experience was negatively correlated with lower educational
level ($r = -.381, p < .05$) indicating that those educators working longer are generally prepared at the masters level, while more recent entrants into the nurse faculties have higher credentials. The conclusion that the higher educational preparation of younger faculty is related to higher performance on inductive reasoning and associative memory tests does not appear illogical, but these relationships should be examined in future studies.

Teaching experience was positively correlated with the preceptive information processing mode ($r = .322, p < .05$) and negatively correlated with the receptive processing mode ($r = -.322, p < .05$). The conclusion to be drawn from this finding is that teachers with greater experience tend to categorize incoming data, while those with less experience tend to gather information in discrete units. The above conclusion does raise the interesting question of whether information processing modes change with increasing experience.

In examining the relationship of performance on cognitive ability tests with information processing style no significant differences were found between preceptive-systematic, preceptive intuitive, receptive-systematic and receptive-intuitive style groups in performance on the verbal, inductive reasoning, associative memory, visuospatial, fluency and originality tests. The conclusion, therefore, is that all style groups performed equally well on tests. Since no studies have been done utilizing the two concepts described above, no comparisons can be made.

The examination of the relationship of the type of subject taught with performance on six cognitive ability tests was accomplished. It was found that when examined in a combined unit groups of educators
teaching medical-surgical nursing, maternal-child health nursing, psychiatric nursing, community health and administrative principals did not differ significantly in their performance in the verbal, inductive reasoning, associative memory, visuospatial, fluency and originality tests. When each test was examined separately the visuospatial factor did discriminate between teaching responsibility groups (p < .02). However a post-hoc test failed to detect a significant difference between any two of the teaching groups. The conclusion to be drawn from this analysis is that there is a suggestion that teachers with different teaching responsibilities may perform differently on cognitive ability tests, but that difference in the sample population was so small that it could not be detected.

Successful problem solvers were examined to determine if performance on the six cognitive ability tests could explain or predict successful problem solution. The amount of variation in time that can be explained by the six dependent variables (cognitive ability tests) operating jointly is 22% which was insignificant. Over half of the variation can be accounted for by performance on the originality test ($R^2 = .119$). One could conclude that performance on cognitive ability tests cannot predict which subjects will complete the problem in a shorter time, however, if any test were to be used for that purpose, the originality test would be the one of choice.

**Question 2.** Do high and low level performers on cognitive ability tests use different information processing modes?

Hypothesis three is directed to this question. High and low performers on cognitive ability tests were examined on each of the four
information processing mode—perceptive, receptive, systematic and intuitive. A linear regression analysis failed to reveal any significant regression coefficients among the groups examined leading to the conclusion that there is no significant relationship between high and low performers on cognitive ability tests and the information processing mode used by subjects in solving the Nine Square Problem.

**Question 3.** How do successful and unsuccessful problem solvers differ in terms of performance on cognitive ability tests, age and information processing style.

A multivariate analysis examining the difference between successful and unsuccessful problem solvers and their performance on six cognitive ability tests failed to achieve significance. When each test was examined separately the associative memory test was found to discriminate between the two groups (p < .04). The conclusion to be drawn from this analysis is that the six measurements, when combined, could not be used to differentiate between successful and unsuccessful problem solvers. If any one test could be utilized for this purpose, the associative memory test (CT) would be the one of choice. In previous studies cognitive ability factors identified with successful problem solving varied with the type of problem. Inductive reasoning ability was found to be important in concept attainment problems (Dunham and Bunderson, 1969), verbal comprehension in algebra problems (Aiken, 1971), spatiovisual skills in anagram problems (Gavurin, 1967) and ideational fluency and originality in originality in a variety of problems (Houtz and Speedie, 1978; Houtz, Montgomery and Kirkpatrick, 1979). Associative memory skills have not been examined in research as it is a recently developed test.
When age was examined in conjunction with problem solving success only a weak negative relationship was observed \( r = -0.042, p < 0.761 \) which was not significant at the \( p < 0.05 \) level. According to the findings in other studies one would expect a stronger negative relationship (Rabbitt, 1977; Craik, 1977). Since educational level is an important factor in the maintenance of intellectual abilities (Green, 1969) it is not surprising that the well educated subjects in this study were not much affected by age differences.

Hypothesis 6 addressed the question of whether a subject's cognitive style was associated with success or failure in solving the Nine Square Problem. Keen (1973) had hypothesized that subjects who were receptive-intuitives would be more efficient in solving invention type problems such as the Nine Square problem. The findings in this study did not bear this out. Only 16.7% of the fifty-four subjects were classified as receptive-intuitive; and of that group 11.1% did not solve the problem while 5.6% solved the problem. In fact the chi square test showed there was little association between the subjects' cognitive style and his performance in problem solving \( \chi^2 = 3.90, (df = 3), p < 0.27 \).

Discussion and Recommendations

The number of significant relationships between the variables investigated was small in comparison to the number investigated. However, this study uncovered some interesting findings and supported research done by others. Of the six cognitive ability factors, only the originality (DU) factor showed a relationship to the information processing
mode used by subjects. The originality measure is positively correlated with the receptive measure and negatively correlated with the preceptive measure. This would indicate that the more creative individuals tend to solve problems by gathering "bits" of information, suspending judgment and interpretation until data are gathered. The brainstorming technique, popular with adult educators, is an example of the receptive information processing technique. Certainly, this technique could be incorporated, along with others, into teacher education courses to demonstrate its usefulness in problem solving. Furthermore, research should be done that will confirm the findings of this study.

Another interesting finding is that greater teacher experience is related to increased use of the preceptive information processing mode rather than the receptive information processing mode. Several questions arise with this finding: Is this true with other teacher populations; and if so, why? Is it that increasing the quantity and differentiation of information acquired over time is likely to lead to the categorization type thinking patterns? Is this finding really a confirmation of the explanation given by Horn (1978), that rigidities occur in the knowledge system when they become more differentiated with age, so that preceptive thinking modes may be a manifestation of these rigidities? As with most exploratory studies, questions are generated by the findings which require further research for explanation.

The relationship of age with associative memory, inductive reasoning and verbal ability in this study were as expected. Verbal skills in this intelligent sample population remained intact as found previously in studies by Green (1969) and Birren and Morrison (1961). The
A moderate negative correlation of age with inductive reasoning and associative memory has also been confirmed by Rabbitt (1977) and Craik (1977). These findings also confirm the fact that those abilities associated with fluid intelligence are more likely to decline with age while those associated with crystallized intelligence, such as verbal ability will show the least decline with age (Horn and Cattell, 1967; Cattell, 1971; Nesselroade, Schaie and Baltes, 1974 and Horn, 1976).

No significant relationships were found with information processing style and performance on cognitive ability tests. Inductive reasoning ability approached significance with indications that the differences lie between the preceptive-systematic and preceptive-intuitive style groups. There were also no significant findings when examining subjects cognitive style with performance in problem solving. The entire issue of information processing mode and information processing style is one which needs more research. Previous research on the McKenney-Keen model used cognitive factor tests to determine placement along the information gathering and information manipulation dimension and consequent style determination. If one accepts the difference between cognitive ability, cognitive strategy and cognitive style, as delineated in the definition section of this study, the use of cognitive ability tests for placement into style categories is unjustified. For this reason, a new questionnaire was developed for this study which is based exclusively on the types of behaviors associated with each information processing mode; and responses were used to determine placement into style categories. Self report of thought processes has its
drawbacks, particularly in the subjects' awareness of subconscious processes (Baron and Tremain, 1980). Therefore, a more objective method for measuring information processing activity along the two dimensions should be sought by future investigators.

Aside from an examination of the information processing model and its measurement, replication of the study is recommended with a larger population. There is a suggestion in several of the findings that, where results have not achieved significance, use of a larger population may have resulted in significant findings. For example, the multivariate analysis of differences between problem solvers and non-solvers and performance on tests resulted in no significant differences, yet when examined univariately the associative memory factor did differentiate between the two groups. The same is true for the differentiation between performance on cognitive ability tests and teaching responsibility groups. If one looks at the contingency table on page 87 several of the style categories, particularly preceptive-systematic and receptive-systematic show large differences in the number of subjects in those categories; but the differences were not statistically significant. It is possible that replication with a larger population would show that a significant difference does exist.

One additional question exists which would be worthy of further exploration. Can the results be replicated with teachers in other disciplines and in the adult population at large? Since problem solving is such a universal activity any research that could increase understanding of this complex mental operation would be welcomed.


_________. *How shall we study individual differences?—methodological and theoretical perspectives*. Intelligence, 1978, 2, 87-115.


Maier, N. and Janzen, J. Are good problem solvers also creative? Psychological Reports, 1969, 24, 139-146.


Shavelson, R.J. What is the basic teaching skill? *Journal of Teacher Education*, 1973, 24, 144-151.


Appendix A

Cognitive Tests
EXTENDED RANGE VOCABULARY TEST

This is a test of your knowledge of word meanings. Look at the sample below. One of the five numbered words has the same meaning or nearly the same meaning as the word above the numbered words. Mark your answer by putting an X through the number in front of the word that you select.

jovial
1-refreshing
2-scare
3-thickset
4-wise
X-jolly

The answer to the sample item is number 5; therefore an X has been put through number 5.

Your score will be the number marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the answer choices as wrong. You will have 6 minutes to complete this test.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.
LETTER SETS TEST

Each problem in this test has five sets of letters with four letters in each set. Four of the sets of letters are alike in some way. You are to find the rule that makes these four sets alike. The fifth letter set is different from them and will not fit this rule. Draw an X through the set of letters that is different.

NOTE: The rules will not be based on the sounds of sets of letters, the shapes of letters, or whether letter combinations form words or parts of words.

Examples:

A. NOPQ DEFL ABCD HIJK UVWX
B. NLIK PLIK QLIK THIK VLIK

In Example A, four of the sets have letters in alphabetical order. An X has therefore been drawn through DEFL. In Example B, four of the sets contain the letter L. Therefore, an X has been drawn through THIK.

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

You will be allowed 7 minutes to complete this test.
PAPER FOLDING TEST

In this test you are to imagine the folding and unfolding of pieces of paper. In each problem in the test there are some figures drawn at the left of a vertical line and there are others drawn at the right of the line. The figures at the left represent a square piece of paper being folded, and the last of these figures has one or two small circles drawn on it to show where the paper has been punched. Each hole is punched through all the thicknesses of paper at that point. One of the five figures at the right of the vertical line shows where the holes will be when the paper is completely unfolded. You are to decide which one of these figures is correct and draw an X through that figure.

Now try the sample problem below. (In this problem only one hole was punched in the folded paper.)

The correct answer to the sample problem above is C and so it should have been marked with an X. The figures below show how the paper was folded and why C is the correct answer.

In these problems all of the folds that are made are shown in the figures at the left of the line, and the paper is not turned or moved in any way except to make the folds shown in the figures. Remember, the answer is the figure that shows the positions of the holes when the paper is completely unfolded.
Your score on this test will be the number marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage ot guess unless you are able to eliminate one or more of the answer choices as wrong.

You will have 3 minutes to complete this test.

DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.
CALENDAR TEST

This is a test of your accuracy in following directions. Each direction will ask you to find a date on a calendar which is printed on the last page of this booklet.

In this calendar you are to remember that:

1. A circled number is a holiday
2. Saturdays and Sundays are weekend days
3. All days except holidays and weekends are work days
4. The first day of Spring is March 21
5. The first day of Summer is June 21
6. The first day of Fall is September 21
7. The first day of Winter is December 21

Look at the sample items below. Put an X on the letter in front of the correct answer.

S M T W T F S
1 2 3 4 5
6 7 8 9 10 (11) 12
13 14 15 16 17 18 19
20 21 22 23 24 25 26
27 28 29 30

I. What is the third Tuesday of the month?
   a. 15th  b. 17th  c. 22nd  d. 24th  e. Not given

II. What is the third working day after the holiday?
   a. 13th  b. 14th  c. 15th  d. 165th  e. Not given

III. What is the seventh working day after the third Monday of the month?
   a. 9th   b. 27th  c. 29th  d. 30th  e. Not given

The answers are I, a; II, d; III, d.
Your score will be the number of dates you mark correctly minus a fraction those marked incorrectly. Therefore, it will not be to your advantage to guess unless you have some idea about which date is correct. You will have seven minutes to complete the test.

Tear off the last page of this booklet now so you will be able to refer to that calendar easily as you take the rest of this test.
This is a test of your ability to think up a number of different symbols that could be used to stand for certain words or ideas.

Look at the example below. The word is food. A sketch has been made to represent a fork and spoon. Can you think of other symbols that could represent food? Draw them in the boxes.

Food:

Each drawing can be as complicated as you choose. However, your score on this test will be the number of different symbols you draw. Therefore, you should not spend too much time on any one symbol or set of symbols.

The test asks you to think of five symbols for each of five words or ideas. You will have 5 minutes to complete the test.
DIFFERENT USES

In this test you are to think of different uses for common objects.

Each item will consist of the name of a common object and, in parentheses, a description of its usual use. You are to think of other ways in which the whole object, or parts of it, can be used. Write these uses on the lines provided.

Look at the example below:

MAGAZINE (used for reading)

Other uses:

- swat mosquitoes
- start a fire
- make paper fans

Try to think of as many different uses (up to six) as you can for each object. Each use that you give must be really different from the others. For example, in the item above, you could not receive credit for both "swat flies" and "swat mosquitoes."

Your score on this test will be the number of acceptable responses which you give.

You will have 5 minutes to complete the test.
Appendix B

Faculty Communication and Questionnaire

B-1 Letter to faculty
B-2 Synopsis of oral presentation prior to participation
B-3 Teacher subject consent form
B-4 Faculty Questionnaire
To Faculty

From Eleanor Reibel, R.N.

Various authors have described problem solving and decision making as important teaching functions. However, there has been little research examining how individual differences in cognition influence problem solving behavior. As a Ph.D. candidate and nurse educator I am interested in studying this issue using nurse educators as subjects.

For the findings in such a study to be meaningful, it is imperative that a large number of faculty participate. I am appealing to you to come to the

________

to learn more about the research and participate as a subject in the study. The entire process will take about an hour (and fifteen minutes) of your time. Your cooperation in this matter will be very much appreciated. Thank you.
Synopsis of Oral Presentation

Prior to Subject Participation

1. Importance of teacher decision making and problem solving
2. Influence of cognitive skills in problem solving
3. Purpose of study is:
   a) to examine the relationship between cognitive
      skills and problem solving performance
   b) to examine the relationship between demographic
      variables, cognitive skills and problem solving
      activity
4. Data collection instruments:
   a) Six short cognitive tests
   b) Problem and problem solving questionnaire
   c) Faculty questionnaire
5. Approximate length of time = 1 hour and 15 minutes.
Consent for Participation

I consent to participate in a study examining the relationship between specified cognitive functioning, problem solving activity and biographic variables. Eleanor Reibel has explained the purpose of the study and procedures to be followed.

I acknowledge that I have had an opportunity to obtain additional information regarding the study and that any questions I have raised have been answered to my satisfaction. I understand that I may withdraw my consent at any time and discontinue participation in the study without prejudice to me. The information obtained from me will remain confidential and anonymous.

Finally, I acknowledge that I have read and fully understood the consent form and have signed it freely and voluntarily.

Date: ___________________________________________  Signed: ___________________________________________  Participant
Faculty Questionnaire

1. List the number of years you have been employed as a teacher in a school of nursing. For part time work, list approximate number of hours worked per week.

   Years (full or part time) ______
   Part time (hours per week) ______

2. List course titles for those subjects you are teaching this quarter. If you are not teaching this quarter/semester, list those courses you taught your last teaching quarter/semester.

3. Year of birth ______

4. Educational level—Indicate the last degree obtained.
Appendix C

C-1 Verbal Instructions to Subjects Prior to Solving the Problem
C-2 Nine Square Problem Sheet
C-3 Problem Solving Strategy Questionnaire
C-4 Assigned Categories for Choices Made by Subjects on the Questionnaire
Verbal Instructions to Subjects Prior to Solving the Problem

Your next task will be to solve a problem. The problem contains nine squares in which you are to place numbers (1-9 used only once) in such a way that any three vertical, horizontal or diagonal numbers totals 15. On the lower part of the sheet there are four quadrants marked with roman numerals I to IV. As you solve the problem show your work, beginning in quadrant I. You will be asked to move to another quadrant after a time.

When you have solved the problem note the letter or letters the investigator is holding at the time and put that letter in the small square in the upper right part of the sheet. Then put the solution in the space provided at the top of the page.

On completion of the above task, complete the questionnaire on the following page. You may use any information in the four quadrants on the problem page to "jog" your memory.

Your final task is to fill out the faculty questionnaire.

I wish to thank you very much for volunteering your participation.
The Nine Square Problem

In the squares below place one to nine numbers (1-9 used once) in each space so that the three numbers in each vertical, horizontal or diagonal column totals 15. Show all your problem solving efforts in the quadrants indicated by the researcher in the quadrants at the bottom half of the page. When you have solved the problem, put your answer in the space provided below on the left. In the square on the right put the letter shown on the card in the front of the room.

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Put solution here

I  |  II
---|---
III| IV
Strategy Questionnaire

In the questions below, circle the statement which is more descriptive of your problem solving behavior.

In solving the problem I:

1. a. started by thinking of possible ways to explain what was need, or
   b. examined the set of data before making a decision bout how to proceed

2. a. decided to attack the problem by using a specific strategy, or
   b. randomly placed numbers in the squares hoping I'd reach a total of 15

3. a. wrote down or thought of all the numbers to be considered, or
   b. looked for cues of possible patterns in the numbers

4. a. tried a number of alternative approaches in quick succession, or
   b. tried one approach until I exhausted its possibilities

5. a. thought of possible implications of high and low or odd and even numbers, or
   b. thought in terms of the totals of combinations of numbers

6. a. searched for a particular way to proceed, or
   b. sought alternatives of action in light of problem demands
7. a. thought of nine squares that make up a larger square, or
   b. thought of a large square composed of smaller squares

8. a. explored and abandoned a number of approaches quickly, or
    b. followed through with one strategy until I was convinced it
       would not work

9. a. started with the expected total of 15 and considered 3 numbers
       adding up to that total, or
    b. started with a specific number and proceeded to find two
       others totaling 15

In solving the problem I could describe the solution in terms of:

10. a. what alternatives seemed plausible in terms of the problem, or
     b. the strategy I used

Have you ever had occasion to see or do this problem before? (Check
    one)

   Yes _____   No _____

Did you use any other strategy that does not appear in the questions
above?

Please explain:
Assigned Categories for Choices Made by Subjects on the Questionnaire

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