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THE DYNAMICS OF SOLVING SELECTION-TYPE, ILL-DEFINED PROBLEMS BY IN-SERVICE TEACHERS

by

Jane Elizabeth Rabb

A Thesis
submitted to the School of Graduate Studies
of the University of Ottawa
in partial fulfillment of the requirements
for the Degree of Doctor of Philosophy in Education

UNIVERSITÉ D'OTTAWA
UNIVERSITY OF OTTAWA

DEDICATION

To my father

for sharing his life and vision

THE DYNAMICS OF SOLVING

SELECTION-TYPE, ILL-DEFINED PROBLEMS

BY IN-SERVICE TEACHERS

by

Jane E. Rabb

The present study was designed to investigate the processes and patterns that developed while problem solvers solved selection-type, ill-defined problems. The structure of such problems consisted of a description of the problem followed by several options. The problem solvers' task was to solve the problem outlined in the main description by considering given options and making a final selection.

Two instruments were used in this study. The first was 'The Knowledge Accessing Modes Inventory' (K.A.M.I.). This instrument was used to classify subjects into noetic, empirical, rational knowledge accessing mode categories. The second instrument was a collection of three complex, educationally relevant, selection-type, ill-defined problems constructed by the researcher.

This study was restricted to in-service, post-secondary teachers possessing a minimum of two years of teaching experience. The sample consisted of 48 subjects: six balanced groups determined by a combination of gender and knowledge accessing mode categories. These forty-eight subjects were asked, individually, to solve out-loud three educationally relevant, selection-type problems. Their verbalizations (protocols) were taped, transcribed, and analyzed.

The objectives of this study were: 1) to determine the criteria an individual introduced or contributed to the definition of the problem; 2) to determine how an individual integrated the above criteria; 3) to determine the patterns and solution strategies that were used to solve the problem; and 4) to determine if there was a relationship between an individual's problem solving behaviour and his/her knowledge accessing mode. These problem solving behaviours referred to strategies, solution patterns, selection and introduction of criteria, and final selection.

Descriptive statistics, chi-square tests, and multivariate and univariate analysis of variance were performed on the data. The adopted level of significance was 0.05.

The number of steps required to solve each problem by each problem solver was identified. In regards to the number of steps required to solve the problems, no association was found between the number of steps required and the knowledge accessing mode of the problem solver.

Each step of the problem solving process was timed. An association between total solution time and knowledge accessing mode was found. The noetic problem solvers were distinct and displayed a different time pattern.

All problem solvers, introduced or contributed criteria to the definition of the problem. This was achieved by adding criteria from personal resources, by highlighting criteria contained in the problem environment, or a combination of both.

No association was found between the introduction of criteria and the knowledge accessing mode. Criteria were introduced during and after the elements of the problem had been reviewed.

Five strategies for solution were identified. The strategy most often used by the problem solvers in this study involved reviewing all elements of the problem before attempting a solution to the problem. An association was found between strategies and knowledge accessing mode. Empirical problem solvers were distinct and displayed a different strategy pattern.

Solutions to the problems had the potential of being associated to the knowledge accessing mode of the problem solver. However, no association was found between solutions to the problems and knowledge accessing mode.

A global profile of the problem solving behaviour of the problem solvers was established. The variables in this profile included: 1) the time and time patterns required to solve the problems; 2) the number of steps and step patterns required; 3) the strategies and strategy patterns selected; 4) criteria introduced to the problem definition and the patterns of introduction; and 5) the final selections and selection patterns to the problems. The strategy chosen and the total time required to solve the problems emerged as important components when describing problem solving behaviours.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

PROBLEM SOLVING AND EDUCATION

The skills of thinking, reasoning, and problem solving are important if individuals are to cope effectively in a world rich in complexity, change, and knowledge. Will the uneducated people of the future be those who have failed to learn these skills?

Educational assessments repeatedly reflect that the skills of thinking, reasoning and problem solving are among the most difficult to impart to students (Kuhn, 1986). Gerjuoy, in an interview with Toffler (1971), emphasizes that education must teach individuals to classify and reclassify information, to evaluate its veracity, to move from the concrete to the abstract and back, to look at problems from a new direction, and to teach him/herself. Simon (1980) urges that teaching responsibilities need to accommodate transfer training. If education moves in this direction, it is essential that teachers understand the principles of information processing as well as the dynamics of problem solving.

The educational domain provides a rich environment in which problems and problem solving behaviours, as they relate to human information processing, can be investigated. One type of problem prevalent in, but not exclusive to education, is the problem faced by individuals given the arduous task of considering a specific number of viable options and solving the problem by

arriving at a final selection. For example, whenever teachers consider a text book for a course, whenever students consider the merits of several candidates for student council president, or whenever administrators interview for new personnel, the task of making a choice arises. Considering such tasks, several questions come to mind. What do individuals introduce or contribute to the definition of the problem? How do individuals integrate their contributions to arrive at a solution? What strategies are used to arrive at a solution? Is there a relationship between the strategies used and the individual's learning style? These are some of the questions addressed throughout this research.

Research Objectives

This research explores the processes and patterns that develop when individuals solve selection-type, ill-defined problems. A problem, where the solution depends on a final selection from viable alternatives is referred to, in the present study, as a selection-type problem. This type of problem is ill-defined because the problem solver must contribute to the problem definition by taking an active role in specifying the problem (Hayes, 1978).

Exploration of the dynamics of solving selection-type, ill-defined problems, within the context of this study, can be considered from a macroscopic perspective and from a microscopic

perspective. A macroscopic perspective looks at an individual's cognitive style or dominant knowledge accessing mode to determine if there is a relationship between the problem solving behaviour and the dominant modality.

The literature provides instruments to profile the cognitive style or dominant knowledge accessing mode of an individual (Briggs Myers, 1980; Kolb, 1976; Lawrence, 1984; Rancourt, 1986; Royce, 1983). Some authors also claim that cognitive style or knowledge accessing mode provides information to operationalize strategies for solving problems (DeBono, 1982; Newell and Simon, 1972; Schoenfeld 1985).

A microscopic perspective, on the other hand, looks at what an individual introduces or contributes to the definition of the problem, how an individual integrates his or her contribution to arrive at a solution, as well as the strategies that are used to solve the problem. If a more detailed understanding of processes and patterns of problem solvers is desired, a microscopic perspective should be considered. The present research uses an exploratory approach to investigate these processes and patterns within the context of selection-type, ill-defined problems.

Specifically, the objectives of the present research are

1. To determine the criteria an individual introduces or contributes to the definition of the problem.
2. To determine how an individual integrates the above criteria to arrive at a solution.

3. To determine the strategies that are used to solve the problem.

4. To determine if there is a relationship between an individual's problem solving behaviour and his/her dominant knowledge accessing mode. These problem solving behaviours refer to the selection and introduction of criteria, solution patterns, choice and application of a strategy, and final solution.

Research Procedures

Population and Sample

This study is restricted to in-service, post-secondary teachers, possessing a minimum of two years of teaching experience. The sample consists of 48 subjects (six balanced groups determined by a combination of gender and dominant knowledge accessing mode catagories).

Instruments

Two instruments are used in this study. The first instrument is the 'Knowledge Accessing Modes Inventory' (K.A.M.I.) (Rancourt, 1986). The second instrument is a collection of three complex, educationally relevant, selection-type, ill-defined problems constructed by the researcher.

Procedure

The Knowledge Accessing Modes Inventory (K.A.M.I.) was administered to a number of subjects to ensure three groups of sixteen subjects. Each group represented one dominance out of the three knowledge accessing modes; noetic, empirical and rational; and each group was balanced in regards to gender. These forty-eight subjects were asked, individually, to solve out loud three educationally relevant selection-type, ill-defined problems. Their verbalizations (protocols) were taped, transcribed, and analyzed.

Type of Data

Protocol analysis was used to investigate the thought processes of the problem solver while solving a problem.

A coding grid was devised, from content analysis of the protocols, to categorize the statements articulated by the problem solver while solving each problem. These categorizations made it possible to identify the strategies used by each problem solver. These patterns were contrasted across groups and gender.

Limitations of the Study

The following limitations were recognized, and measures were taken to eliminate or minimize their effect:

1. The difficulty of verbalizing all mental activity while solving a problem.
2. The fatigue factor of the problem solver.
3. The limitations of exploratory research which includes the inability to manipulate the independent variables and the risk of improper interpretation.
4. The limitations of protocol analysis. There are processes that occur during the performance of a task which a subject cannot or does not report.

Scope of the Study

The following restrictions have been imposed on this study:

1. The sample was limited to subjects from a post secondary educational institution.
2. The subjects taking part in this study were in-service teachers, possessing a minimum of two years of teaching experience.

Justification for the Study

By applying the principles of information processing to education and understanding the dynamics of problem solving, educators will begin to understand how people process information and, hence, comprehend the actual strategies people use to solve problems. From the standpoint of educational policy, it would be desirable to determine a the teach-ability of problem solving. Achievement of this objective is one of the reasons research in the problem solving area is important.

Format

In the following six chapters, the researcher will describe the study in detail. In Chapter II the author presents a focused review of the literature including a discussion on information processing as a general framework for understanding human problem solving behaviour. The author includes a discussion on selection-type, ill-defined problems and their relationship and applicability to the information processing framework. In Chapter III the author focuses on the methods and procedures for the investigation. In Chapter IV the author delineates the preparation of the data for analysis. In Chapter V the author presents and interprets the findings. In Chapter VI the author discusses the conclusions and recommendations based on the study.

Definition of Terms

Coding Grid: A categorizing tool used to score a protocol.

Complex Ill-Defined Problems: A problem comprised of many elements where the problem solver takes an active role in specifying the problem by making necessary choices not delineated in the problem description and by making tentative problem solving attempts designed to reveal the nature of the problem (Hayes, 1978).

Empirical Knowledge Accessing Mode: A view of reality largely determined by a commitment to sensory perceptions as the main source of data collection and an inductive process of reasoning in determining whether the data is to be accepted as knowledge (Royce, 1983).

K.A.M.I.: An instrument designed to categorize people into one of three knowledge accessing modes: noetic, empirical, and rational (Rancourt, 1986).

Noetic Knowledge Accessing Mode: A view of reality largely determined by a commitment to personal or subjective experience as the main source of data collection and an analytical, intuitive reasoning process in determining whether the data is to be accepted as knowledge (Royce, 1983).

Problem: The recognition of a gap between the present state and the goal state (Hayes, 1978).

Problem Solving: The procedures used to comprehend the gap separating the present state from the goal state and the procedures used to bridge this gap (Hayes, 1978).

Protocol: A description of the activities, ordered in time, in which an individual engages while performing a task (Hayes, 1981).

Protocol Analysis: A technique used to investigate the thought processes of a person performing a task (Hayes, 1981).

Rational Knowledge Accessing Mode: A view of reality largely determined by a commitment to concepts or information currently available as the main source of data collection and a deductive process of reasoning in determining whether the data is to be accepted as knowledge (Royce, 1983).

Selection-Type Problem: A type of complex, ill-defined problem where the solution depends on a final selection from viable alternatives.

Focused Interview (SDFI): An alternative to written methods of data collection, involving the asking of general questions from a prepared interview schedule. SDFI is open-ended, allowing subjects to identify and discuss items which they view as being relevant.

Strategies: General suggestions that help an individual better understand a problem or to make progress towards its solution (Schoenfeld, 1985).

CHAPTER 11

FOCUSED REVIEW OF THE LITERATURE

The term 'focused' implies that the review of the literature is primarily a clarification of the issues surrounding problem solving behaviour. Although an 'ERIC' and 'PSYCINFO' search (August, 1988), accompanied by a manual search of the literature was conducted by the researcher, the searches did not produce articles which addressed, specifically, the objectives of this research. The searches, however, did generate an abundance of global information pertaining to problem solving, decision making, information processing, cognitive styles, and strategies. The bibliography, therefore, is extensive and includes references not cited in the literature review. Nonetheless, all references found in the bibliography were used to 1) identify and formulate the research objectives; 2) design the experimental methodology; and 3) provide necessary background information.

Throughout the review of the literature, the researcher explores the nature of problems. In doing so, the factors that determine whether problems are simple, complex, well-defined, or ill-defined in the eyes of the problem solver are discussed. Within this review, information processing is presented as a general framework for understanding human cognition and problem solving behaviour. It is this information processing framework which currently dominates the cognitive psychology field and

describes problem solving behaviour as an interaction between the information processing system and the problem solver (Newell and Simon, 1972). Furthermore, the review reiterates the objectives for the present study as they relate to information processing and human problem solving behaviour. The final section within the review addresses the methods used to study problem solving behaviour and highlights the technique of protocol analysis.

The Nature of a Problem

In describing the nature of a problem, it is necessary to focus on a definition of a problem and the basic components comprising a problem. In addition, a distinction is made between simple versus complex problems, and well-defined versus ill-defined problems.

Definition of a Problem

Fundamentally, a person is faced with a problem when something is wanted but cannot be immediately attained. The situation creates a gap between the present state and the goal state, hence requiring steps to resolve the gap (Gick and Holyoak, 1979; Schoenfeld, 1985). While problems can be diverse, all types of problems are comprised of three basic components: 1) a description of the problem; 2) a set of operations or actions that a person can use to achieve a solution; and 3) a

goal, or description of what constitutes a solution to the problem (Gick and Holyoak, 1979). To solve problems, the problem solver passes through a series of 'states of knowledge' from the time one begins to work on the problem (initial state) and the time one actually achieves a solution to the problem (goal state).

Simple Versus Complex Problems

As previously stated, a problem may be simple or complex for a problem solver. If the problem is simple, the problem solver perceives the problem to be comprised of few elements and sees a clear cut solution to the problem. However, if the problem is complex, the problem solver perceives the problem as having many elements requiring a substantial amount of time to reach the goal; at least several seconds, often minutes or hours, sometimes years (Gick and Holyoak, 1979). In a complex problem, the solution is not automatic. There may be false starts, dead ends, and many intervening steps before a solution is actually achieved.

Well-Defined Versus Ill-Defined Problems

Problems can also be classified as being well-defined or ill-defined (Hayes, 1978; Newell and Simon, 1972; Simon, 1973). A well-defined problem is one in which the steps to the solution can be clearly specified by the experiment and ultimately by the problem solver. Furthermore, the problem can stand alone such that the problem solver is not required to contribute any additional information to further define the problem. Problems of this kind require a series of moves and once insight into the pattern of moves has been achieved, the solution to the problem becomes automatic (Sternberg, 1985).

Many of the problems that humans encounter and solve in every day life are not well-defined but, rather, ill-defined. At the outset of a solution attempt to an ill-defined problem, a problem solver may possess partial information regarding the initial state, the goal state, and the operators. Ill-defined problems require that the problem solver contribute to the problem definition. The problem solver must, therefore, make decisions based on knowledge and values which fill-in gaps in the problem definition or attempt a solution before fully understanding the requirements of the problem (Hayes, 1978). Ultimately, whether a problem is considered simple, complex, well-defined, ill-defined, or not a problem at all depends on the problem solver and his/her background knowledge.

Past research in problem solving behaviour has concentrated

on studying well-defined problems. A sampling of the kinds of well-defined problems that have been studied include 1) Missionaries and Cannibals Problem; 2) Water Jug Problems; and 3) Tower of Hanoi Problem (Atwood and Polson, 1976; Egan and Greeno, 1974; Ernst and Newell, 1969; Greeno, 1974; Hayes and Simon, 1974, 1976a. 1976b; Jeffries, Polson, Razran, and Atwood, 1977; Reed, Ernst, and Banerji, 1974; Simon, 1975; Thomas, 1974).

In comparison, ill-defined problems have received relatively little attention (Reitman, 1965; Simon, 1973). This particular trend focuses on the fact that well-defined problems are clearly specified and experimentation is controlled. In contrast, ill-defined problems are not easily specified, hence, it is difficult to design experiments to investigate the methods people use to solve ill-defined problems. Since the difference between well-defined and ill-defined problems is not always clear, it can be argued that the study of well-defined problems contributes to our understanding of ill-defined problems. This may indeed be true globally, however, to understand the patterns and processes that develop as a person solves an ill-defined problem, research utilizing ill-defined problems is required. Examples of ill-defined problems that have been studied include 1) Hat-Rack Problem; 2) Two-String Problem; 3) Radiation Problem; and 4) Social Science Problems (Burke and Maier, 1965; Burke, Maier, and Hoffman, 1966; Duncker, 1945; Gick and Holyoak, 1980; Maier, 1970; Raaheim, 1974; Voss, Greene, Post, Prenner, 1983).

Information Processing Framework

Information processing provides a general framework for understanding human cognition. It focuses on specifying mental activities and properties that intervene between the stimulus and the response (Kail and Bisanz, 1982). Adherents to information processing maintain that human cognition is the manipulation of symbolic functioning. The main goals of information processing are to describe the symbols and the way in which these symbols are manipulated. When discussing information processing and problem solving it is necessary to consider the characteristics of the memory structure of human beings, the steps required to solve a problem, and the components or elementary information processes that operate upon the internal representation of objects or symbols.

Memory Structure in Human Beings

Within much of the literature on problem solving, human cognition is accepted as an information processing system (Simon, 1972; Sternberg, 1985). Human beings can, therefore, be characterized by their memory structure.

It is generally agreed that the major components of memory are short term memory (STM), long term memory, as well as a sensory register (Ericsson and Oliver, 1988).

A certain amount of information about a stimulus is

registered in a 'sensory register'; a storehouse limited by the length of time a stimulus can stay without decaying. While in a sensory register, two important processes occur: 1) pattern recognition, a complex process that results in assigning meaning to a stimulus through making a connection between the information in a sensory register and previously acquired knowledge; and 2) attention, a complex process that results in selectively attending to certain aspects of the stimulus.

Once inputs to the sensory register have been recognized and attended to, they may proceed to short-term memory (STM). Information in STM may be held indefinitely by a holding process called 'rehearsal'. Without rehearsal, information in STM is lost through the decaying process. There are two limitations on STM: 1) the number of stimuli that can be held simultaneously in STM with the help of rehearsal; and 2) the length of time an item can stay in STM without rehearsal.

Finally, information may be sent from STM into a relatively permanent storehouse called long-term memory (LTM) (not to be regarded as a specific structure or location in the mind where knowledge resides). LTM is characterized by slow storage and access times compared with the other memories.

Simon (1978) suggests that apart from the sensory organs, this system operates almost entirely serially, one process at a time. In problem solving, it is assumed that the problem solver moves along a solution path until the goal state is reached. This movement is constrained by the limitations of the short-term

memory (3-9 chunks), difficulty in retrieving information from long term memory, as well as attentional resources. To off-set these limitations relevant techniques and procedures are 1) chunking techniques; 2) elaboration of indexing networks; and 3) the development of automatisms (Dionne, 1987).

Steps Required to Solve a Problem

In problem solving, an individual is first presented with an objective problem statement. This statement and the context within which this statement is derived, is called the task environment. Once the problem has been stated, the problem solver establishes a problem space; an internal representation of a task (Simon, 1978). This space consists of information known or potentially known to the problem solver, information useful in solving the problem (such as strategies for solution), and a concept of what the end result should be.

For a number of problems, as in puzzle problems (well-defined problems) (Greeno, 1974; Simon, 1975), it is possible to represent the problem as a sequence of discrete and well articulated states (Sternberg, 1985). In contrast with complex, ill-defined problems, representation is more complicated because the problem solver is faced with uncertainty concerning some or all of the states. As a result, the problem solver must interpret the problem statement by studying the features of the problem and their interrelations.

Problem representation is a major step toward finding a solution to a problem (Gick and Holyoak, 1979). Some representations permit the problem to be solved more easily while other representations create more difficulty when solving problems. The choice of representation can develop differences in problem solving success (Hayes, 1978) and in the strategies selected by the problem solver to solve the problem (Newell and Simon, 1972).

In describing the strategies that are selected by a problem solver to solve a problem, it is important that a distinction be made between algorithms and heuristics (Gick and Holyoak, 1979). An algorithm can be described as a procedure that guarantees a solution to the problem. Heuristic strategies, on the other hand, are 'rules of thumb' for successful problem solving. They represent general suggestions that help an individual understand a problem (Schoenfeld, 1985).

All individuals possess a repertoire of heuristic strategies based on acquired bits of knowledge, learned rules, or hypotheses that have proved beneficial in the past. When one uses heuristics, then, one is essentially saying: "This problem reminds me of problems I have faced previously, so what worked then, ought to work now." Heuristics are, therefore, important in problem solving. As for ill-defined problems, algorithms are not available for solutions.

One of the simplest heuristic strategies known to problem solving is the 'generate-test' method (Newell and Simon, 1972).

This method involves two steps: 1) generating a candidate for a solution; and 2) testing to see whether the candidate is actually a solution to the problem.

Another heuristic strategy frequently used in problem solving is a 'means-ends analysis' (Newell, 1969). This procedure consists of four steps: 1) a comparison of the current state to the goal state and identification of the differences; 2) a selection of an operator relevant to reducing the difference; 3) an application of the operator if possible; and 4) iteration of the procedure until the goal state has been achieved or until some failure criterion is exceeded (Holland, Holyoak, Nisbett, Thagard, 1987).

Exploitation of sub-goals is another general heuristic strategy frequently used in problem solving (Schoenfeld, 1985). In this situation, if a problem solver is unable to solve a given problem, he/she can establish sub-goals or partial fulfillments of the desired conditions. Once this occurs, the problem solver can construct additional sub-goals to solve the original problem. This process of exploiting sub-goals, however, is vague and broadly defined. The successful use of this strategy calls for 1) knowing the strategy; 2) knowing when to use the strategy; 3) knowing how to use the strategy; 4) generating related, but simpler problems; 5) assessing the likelihood of being able to solve the simpler problems; 6) assessing the likelihood of being able to use the solutions to the simpler problems to solve the main problem; 7) deciding which of the simpler problems to solve

first; 8) solving the simpler problems; and 9) solving the main problem.

Over a period of years each person develops a personal and idiosyncratic collection of problem solving strategies. While idiosyncratic, the development of problem solving strategies is somewhat uniform. Although not extensively researched with regards to practical ill-defined problems, it is speculated that parsimony exists among the methods used by problem solvers when approaching problems (Schoenfeld, 1985). This does not imply that two people will approach a problem in exactly the same way. It implies, rather, that the strategies used overlap. According to Schoenfeld (1985), the choosing of an heuristic is critical. If the problem solver is unable to choose or recover from incorrect choices, the potential benefits of heuristics are lost.

The determination of exactly when a correct solution has been obtained is inherent in many well-defined and ill-defined problems. However, the accuracy of solutions to some problems may not be clearly defined. As a result, the problem solver must then decide between alternatives by evaluating information which is favorable or unfavorable to each alternative. This commonly involves the formation of judgments which is often done intuitively. Tversky and Kahneman (1974) have identified two heuristics to provide insight into how intuitive judgments are determined. The first is the 'representativeness heuristic'. As one judges the likelihood of a situation, one intuitively compares it to a mental representation of a prototype of that

category. In so doing, other relevant information may be ignored. The second is the 'availability heuristic'. In this instance, one bases judgment on the availability of information within memory. In accordance, if instances of a particular situation come readily to mind (perhaps because of their vividness), one presumes the situation to be more likely.

Cognitive Styles/ Dominant Knowledge Accessing Modes

Generally, cognitive style refers to an individual's characteristic and consistent manner of processing and organizing what is seen and what is thought. At least three theories categorize personality dimensions in an hierarchial order and provide an holistic view of cognitive style. These are Kolb's Experiential Learning Theory, Briggs Myers Type Theory, and Royce's Multi-Factor Theory of Personality. All three theories are based on the Jungian approach and provide instruments to profile the cognitive style.

Kolb (1984) defines cognitive style as the process by which individuals organize information and experience. The accompanying 'Learning Style Inventory' differentiates four dimensions of learning 1) concrete experience (feeling), 2) abstract conceptualization (thinking), 3) active experimentation (doing), and 4) reflexive observation (watching). Combinations of these four dimensions result in four styles referred to as converger (thinking and doing), diverger (feeling and watching),

assimilator (thinking and watching), and accommodator (feeling and doing).

Briggs Myers (1980) concentrates on people's patterns of dealing with the world. The accompanying 'Myers-Briggs Type Indicator' identifies four dimensions of type: 1) extraversion/ introversion; 2) sensing/intuiting; 3) thinking/feeling; and 4) judging/perceiving. One is dominant over the other resulting in sixteen different personality types.

Royce (1983) associates cognitive styles with epistemological styles which are characteristic modes of manifesting cognitive and or affective phenomena. He emphasizes that styles and values which express commitments to modes of processing and to the selection of particular processing contents exist at the highest level of psychological functioning. The accompanying instrument, 'Royce's Psycho-Epistemological Profile' provides information on each person's strength in three ways of knowing: 1) empirical knowing relating to the extensiveness of scanning and to the selection of perceiving modes of processing; 2) rational knowing involving the relationship between the abstract characteristics of things and a commitment to conceptual modes of processing; and 3) metaphoric (noetic) knowing relating to breadth of attention and a commitment to symbolizing as a mode of processing. When confronted with a particular learning situation, an individual may be predominately rational, empirical, or metaphorical (noetic) depending upon his/her particular hereditary and environmental characteristics.

Rancourt (1986), took Royce's Multi-Factor Theory of Personality and accompanying Psycho-Epistemological Profile as the bases for the development of a shorter instrument called the 'Knowledge Accessing Modes Inventory'. Like its predecessor, this instrument measures the three ways of knowing (rational, empirical, and noetic) and identifies the dominant modality. As will be explained later, this instrument was used in this present study to categorize subjects into their dominant modality. For this reason, the terms 'knowledge accessing mode' and dominant modality are used in the context of cognitive styles.

It is speculated in the present study that one's dominant knowledge accessing mode (dominant modality) can be associated with how one approaches a problem. Furthermore, one's dominant knowledge accessing mode is likely to be related to the selection of one's problem solving strategies.

Information Processing Components

As previously mentioned, once a problem has been presented, a problem solver develops a problem space, an internal representation of the task. This space includes information pertaining to the goal of the problem, the operators which enable the problem solver to move from one state to the next, and the constraints under which a problem is to be solved. The development of this representation requires distinct cognitive activities operating in concert. These cognitive activities

involve a number of elementary components or elementary information processes that operate on the internal representation (understanding) of objects or symbols (Newell & Simon, 1972; Sternberg, 1988). These elementary components may translate sensory input into a conceptual representation, transform one conceptual representation into another, or translate a conceptual representation into a motor output (Sternberg, 1988). Each component has at least three important properties associated to it: 1) duration, the time required to execute the component; 2) difficulty, the probability of the component being executed correctly; and 3) probability of the component being executed at all (Sternberg, 1985). In isolation, these components are insufficient to account for human cognition.

There are several theories depicting the organization of the information processing components. Brown (1978), Carrol (1976), Dionne (1985), Kitchener (1983), Newell and Simon (1972), and Sternberg (1985) represent only a few. It is important that the approaches of Sternberg and Dionne be elaborated upon since they represent starting points and the underlying foundations for branching into new directions.

Sternberg (1985) distinguishes among three kinds of information processing components: 1) metacomponents; 2) performance components; and 3) knowledge acquisition components. Metacomponents are the executive processes responsible for determining how to perform a particular task or set of tasks and then ensuring the task or tasks are done correctly. Some of the

metacomponents prevalent in problem solving are 1) recognizing that a problem exists; 2) recognizing the nature of the problem; 3) selecting a strategy; 4) selecting mental representations; 5) deciding how to allocate attentional resources; and 6) monitoring or keeping track of one's place in the task performance.

Performance components are lower order processes used to implement the plans that the metacomponents formulate. Inferring relations between stimuli, applying previously inferred relations to new stimuli, and mapping higher-order relations between stimuli are some examples of important performance components.

Finally, knowledge acquisition components are the processes that enable an individual to learn new information and store it in memory. The three knowledge acquisition components believed to be most important in problem solving are 1) selective encoding whereby irrelevant information is ignored; 2) selective combination whereby relevant information is combined for internal coherence; and c) selective comparison whereby relevant and combined information is connected to existing knowledge.

Dionne's (1987) global objective, on the other hand, was to integrate diagnostic, intervention, and evaluation procedures in a problem solving model which could be adapted to domain-specific contexts. His approach focuses on information processing, but also deals with processing components. Furthermore, Dionne's model provides the necessary background for interpretation of observations relevant to an educational environment. Figure 1 illustrates the interrelationships of

problem solving components underlying the information processing problem solving models (Dionne, 1987). In this framework, several types of components are identified and coordinated.

Organizational knowledge components refer to processes which are domain specific such as concept differentiation, concept discrimination, structure complexity, and selection of relational structures. Experiential components reflect the ability to deal with novel tasks as well as the ability to automatize cognitive processes. The control and evaluation components involve the processes used in monitoring and evaluating task performance. Metacomponents (planning) refer to processes used for such things as selection of problem representation, selection of solution strategy, and use of heuristics. Performance components refer to processes used in the execution of various tasks such as inductive reasoning, deductive reasoning, analogical reasoning, selective encoding, selective combination, mapping application, comparison, and justification. In both Dionne's and Sternberg's models, as with all models depicting the organization of information processing components, a variety of components are used during task performance.

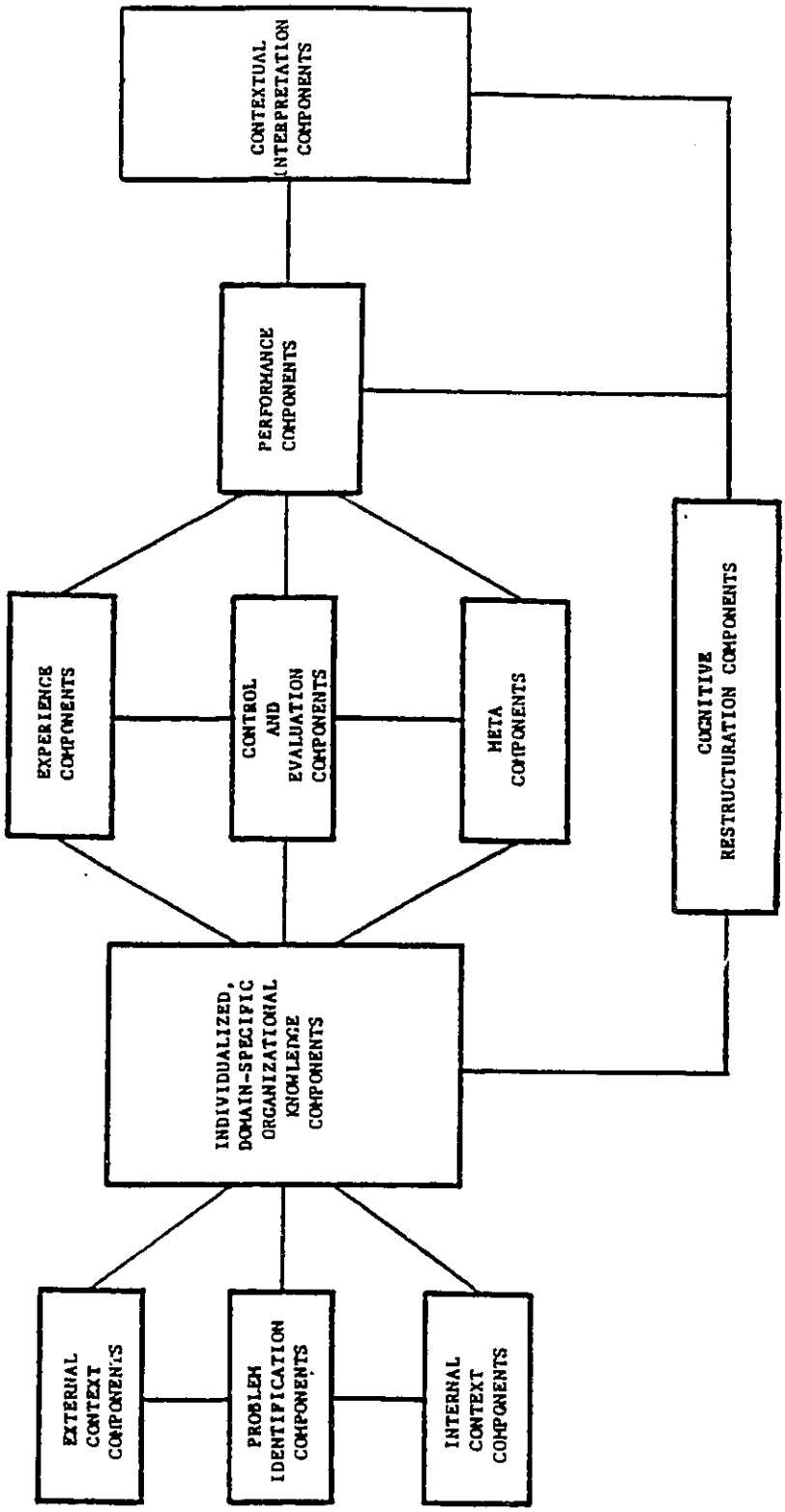

Figure 1 Framework for Depicting the Interrelationship Among Component Categories Underlying Information-Processing Problem Solving Models (Dionne, 1987)

In summary, this research uses the contemporary theory of information processing as its conceptual framework. The researcher, in accordance with other supporters of information processing is concerned with 1) identifying elementary cognitive processes; and 2) determining how such processes are structured to perform a selected cognitive task (Kail and Bisanz, 1982). To solve a complex problem, therefore, the problem solver must develop a problem representation and then offer a solution to the problem via strategies.

Focused Review of the Literature and the Present Study

There are a number of reasons for studying complex, educationally relevant, ill-defined problems. First, such problems focus on recent theoretical developments in problem solving and how these developments extend to education. Second problems encountered in education tend to be complex and ill-defined, and the study of solving such problems has received relatively little attention (Reitman, 1965; Simon, 1973; Sternberg, 1985). Finally, a more thorough understanding of the principles of information processing and the dynamics of problem solving may help improve instruction in the skills of thinking, reasoning, and problem solving.

This problem can be studied from a macroscopic as well as a microscopic perspective. The macroscopic objective, translated here, is to study the potential relationship between problem solving strategy and the dominant knowledge accessing mode of the

problem solver. While the microscopic objectives focus on the coordination of the cognitive processes and patterns of problem solving.

The 'Knowledge Accessing Modes Inventory' (K.A.M.I.) was developed by Rancourt (1986) and was selected to be used in the present study to identify the individual's dominant knowledge accessing mode. This instrument, a shorter instrument than its predecessor, Royce's Psycho-Epistemological Profile (1983), is relevant to education and measures the three ways of knowing: 1) rational; 2) empirical; and 3) noetic.

It is speculated in the literature that a relationship exists between the dominant knowledge accessing mode of the individual and the strategies used to solve problems (Schoenfeld, 1985; Sternberg, 1985), but, this relationship is not addressed directly. Three articles most akin to this present research (albeit two are not current) are "An Information-Processing Approach to Personal Problem Solving" (Heppner & Krauskopf, 1987); "Cognition, Metacognition, and Epistemic Cognition" (Kitchener, 1983); and "Problem Solving Skills in Social Sciences" (Voss, Greene, Post, Prenner, 1983).

Heppner and Krauskopf's article (1987), presented an information processing approach to counselling and the counselling environment. Their information processing view of personal problem solving focused on how people gathered information, processed information into plans for solutions to personal problems, and carried out such plans. In their

discussion, heuristics and cognitive styles were mentioned, but the relationship between the two was not addressed.

Kitchener's article (1983) proposed a three-level model of cognitive processing (cognition, metacognition, and epistemic cognition) to account for complex monitoring when individuals were faced with ill-structured problems (problems on which opposing or contradictory evidence and opinion exists). Kitchener called the first level of cognitive processing, cognition. At this level, individuals computed, memorized, read, perceived, and solved problems. She called the second level of cognitive processing the metacognitive level. At this level, individuals monitored their progress when they were engaged in the first-order tasks. The third level of cognitive processing was called epistemic cognition. At this level individuals reflected upon the limitations of knowing, the certainty of knowing, and the criteria of knowing. Epistemic assumptions influenced how individuals understood the nature of problems. This understanding aided individuals when deciding which strategies were appropriate for solving problems. Kitchener determined that cognitive and metacognitive processes developed throughout childhood and were used throughout the life span while epistemic cognitive monitoring developed in late adolescent and adulthood. Although epistemic cognition was addressed in Kitchener's research, specific epistemic modes were not identified and the relationship between the strategy used to solve an ill-structured problem and an epistemic mode was not

addressed.

Voss, Greene, Post, and Penner's research (1983) was conducted within the framework of the general information processing model of problem solving proposed by Newell and Simon (1972), and dealt specifically with ill-defined, social science problems. In this study, the researchers' investigated how social science problem solving skills developed. The researchers provided a sketch of the processes involved in learning the skill of social science problem solving. In addition, they emphasized the importance of experience in providing ways of organizing information so that it could be utilized during further processing. Protocols were collected and analyzed to investigate the problem solving process. Again, the issue of an individual possessing knowledge structures and the individual's utilization of strategies for solution were addressed, but specific knowledge accessing modes were not identified.

In summary, the above three articles provide guidelines for investigating the ill-defined problem solving process. The articles contribute some information compatible with the global objective of this present research and suggest that a relationship does exist between the dominant knowledge accessing mode of the problem solver and the strategy used to solve a problem. However, the literature does not address this relationship directly. For this reason, the present study uses an exploratory approach to investigate these relationships.

The objective of the present research is to investigate the

metacomponents and performance components prevalent while solving educationally relevant, selection-type, ill-defined problems. The dynamics of solving these types of problems can be addressed from a microscopic and macroscopic perspective. Specifically, within the context of selection-type, ill-defined problems the microscopic objectives of the present study are

Objective 1: to determine the criteria an individual introduces or contributes to the definition of the problem;

Objective 2: to determine how an individual integrates the above criteria in the problem solution;

Objective 3: to determine the strategies and solution patterns that are used to solve the problems.

The macroscopic objective of the study is

Objective 1: to determine whether a relationship exists between an individual's problem solving behaviour and his/her dominant knowledge accessing mode. These problem solving behaviours refer to strategies, solution patterns, introduction or contribution of criteria to the problem definition, and integration of this criteria.

To investigate these research objectives, the type of problem that is required must meet the following criteria: 1) it must represent a practical everyday problem encountered in education and must be familiar to the problem solver; 2) the problem solver must contribute to the definition of the problem from his/her own resources; 3) the problem solver must make decisions based on his/her knowledge and values which fill in

gaps within the problem definition, or the problem solver must attempt a solution to the problem before fully understanding the demands of the problem; 4) the problem must be general in structure but not to the extent that it would be difficult to glean information, and the problem must be specific in structure but not to the extent it would dictate the strategy to be used; 5) the problem must have a sufficient number of elements allowing different options for solution; 6) the problem must lend itself to the extraction of several elements relevant to the problem solver, with the extraction of such elements and the solution to the problem reflecting individual strategies and knowledge accessing modes.

A problem type, prevalent in, but not exclusive to education, that satisfies the above criteria is represented by the selection-type, ill-defined problem. The study of these problem types will contribute to one's understanding of the relationship between the dominant knowledge accessing modes of the individual and the strategies used to solve the problem. In these types of problems, the problem solver is presented with a problem accompanied by a given number of viable solutions. The problem solver's task is to solve the problem by considering one's options and arriving at a final selection from these given options.

The problems in this study present a main scenario which outlines the particulars of the problem as well as the task to be performed. This main scenario is followed by nine mini

scenarios, each containing information the problem solver may perceive as positive, negative or inconsequential, yet necessary to arrive at a solution to the problem. In addition, each mini scenario is representative of one of the three knowledge accessing modes. The problem solver's task is to choose three mini scenarios from nine, he/she feels best answers the problem outlined in the main scenario. The problem solver must also justify his/her choices. Each problem solver is informed that this is the only information available.

For example, in the 'Interview Problem' (Appendix A) the main scenario states that a post secondary school requires a full time, social science teacher. This teacher must be able to teach a variety of subjects as part of the social science curriculum, possess a distinct teaching style, and be an asset to the school. The hiring committee has met, and nine candidates have made the short list. A profile of each candidate has been prepared and presented to the members of the hiring committee. These profiles include information on the candidate such as age, sex, teaching style, years of teaching experience, and so on. Time restrictions prevent the committee from interviewing more than three candidates. The problem is to choose the three candidates that should be interviewed and justify these choices to the committee.

Considering selection-type problems and the three basic components of a problem, the given information includes what is stated in the main scenario and the mini scenarios. This

information, however, may not be precisely determined for the problem solver ("Shall I use the criteria in the main scenario to select my candidates to be interviewed, or shall I select candidates on what I think is important?"). The operations used by a problem solver to achieve a solution to the problem are not precisely determined ("Shall I review all the candidates to be interviewed before I make a selection, or shall I make a selection before reviewing all the candidates?"). Furthermore, the goal state is not precisely determined ("Have I considered everything in my final selection? Will the other members of the hiring committee agree with my selection?"). Nevertheless, the task of selecting three mini scenarios is clearly stated despite there being no right or wrong answers. The problem solver, therefore, must evaluate progress towards a solution and decide whether an acceptable solution has been reached.

The selection-type problems constructed for this study are ill-defined because there is uncertainty surrounding the initial state, the goal state, and the operations. Selection-type problems require that the problem solver further define the problem from his/her resources. In so doing, the problem solver redefines the task and reduces the uncertainty surrounding the initial state, the goal state, and the operations needed to solve the problem.

It was postulated by Simon (1973) that ill-defined problems eventually become a series of well-defined problems for the problem solver. Indirectly, the present research investigates

whether a problem solver represents ill-defined problems by selecting elements from the ill-defined problem and representing these elements as a well-defined problem. The original complex ill-defined problem can be viewed as a sequence of well-defined problems. A solution to this well-defined problem is then obtained. The research also investigates whether the problem solver attacks the problem directly. In other words, does the representation and solution of ill-defined problems occur in two clearly defined steps or in one step? It is speculated that the problem solver will represent the problem in two steps.

In summary, a series of three educationally relevant, selection-type, ill-defined problems were constructed. The objectives of the present research were 1) to determine the criteria an individual introduces or contributes to the definition of the problem; 2) to determine how an individual integrates the above to arrive at a solution; 3) to determine the strategies and solution patterns that are used to solve the problems; and 4) to determine if there is a relationship between an individual's problem solving behaviour and his/her dominant knowledge accessing mode.

Strategies for Studying Problem Solving Behaviour

There are a number of strategies that can be used to study problem solving behaviour. Assuming that the cognitive processes necessary to solve a problem can be described as a sequence of processing steps, observations can be based on 1) the total performance of the task (reaction time and accuracy of the response); 2) the processing performance during the execution of a task (problem solvers are asked to talk-out loud while performing a task); and 3) post processing performance made once the task is completed (problem solvers are asked to remember the thought processes that they used while solving a task) (Ericsson and Oliver, 1988). The identification of different strategies is difficult when one relies exclusively on performance data. Therefore, this type of information, supplemented by process data, particularly the processing performance during the execution of a task can account for cognitive processes at a detailed level of description. It is this detailed level of description that is required when investigating the relationship between the dominant knowledge accessing mode of the problem solver and the strategy used to solve the problem.

The purpose of this study is to investigate the patterns and the processes that people develop as they solve complex, ill-defined problems. Protocol analysis is the best technique to use when investigating the thought processes of a person while he/she

solves a problem. A protocol is a description of the activities, ordered in time, in which a subject engages while performing a task (Hayes, 1981). An essential ingredient of protocol analysis is the examination of patterns and sequences in a continuous stream of behaviour (Byrne, 1983). It can provide a greater 'density of observations' than other techniques (Simon, 1978). It can also provide further information regarding planning goals and sub-goals, criteria for their selection, and criteria for assessment of success (Byrne, 1983).

The techniques of collecting and analyzing protocols have been used in the studies conducted by Anzai and Simon (1979); Kotovsky, Hayes, and Simon (1983); Schoenfeld (1985); Simon and Hayes (1976, 1979); Voss, Greene, Post, and Prenner (1983), to mention a few. Although there are many processes that occur during the performance of a task which the subject cannot or does not report, Ericsson and Simon (1979) offer convincing evidence that think-aloud protocols do indeed reflect the thought processes that occur during task performance and do not distort or interfere with a subject's thinking when performing a task (Hayes, 1981).

Hayes (1981) suggests, however, that the researcher's task when analyzing a protocol is to take the incomplete record provided by the protocol and supplement it with current knowledge of human capabilities. By so doing, the researcher can then infer a model of the underlying psychological processes by which

the subject performs a task. Protocols were utilized in this study to determine what and how a problem solver thinks as he/she solves selection-type ill-defined problems.

CHAPTER III

METHODS AND PROCEDURES

As previously stated, the purpose of this research is to explore the processes and patterns that develop as problem solvers solve complex, educationally relevant, selection-type, ill-defined problems. The following chapter is divided into various sections and outlines the methods and the procedures used to accomplish this investigation. The first section distinguishes the population and sample under study; the second identifies the two research instruments used; the third focuses on the complex, educationally relevant, selection-type, ill-defined problems chosen for this study, and the last section explains the research procedures and the research design.

Population and Sample

The macroscopic objective of the present research is to study the potential relationship between an individual's problem solving behaviour while solving selection-type, ill-defined problems and his/her dominant knowledge accessing mode. The evolution of consistent problem solving behaviours and a dominant knowledge accessing mode requires a degree of maturity and life experience. Since the problems are educationally relevant, this study is restricted to in-service, post-secondary teachers, possessing a minimum of two years of teaching experience.

The sample consists of 48 subjects (6 balanced groups determined by a combination of gender and knowledge accessing mode catagories). In order to secure the 48 subjects, approximately 80 faculty employed in a post-secondary institution and in attendance at a faculty meeting were asked to volunteer as subjects for this study. Of these 80 faculty, 34 willingly agreed to be subjects. These 34 subjects were administered the 'Knowledge Accessing Mode Inventory' (K.A.M.I.) which identified their dominant knowledge accessing mode and were placed into the appropriate group according to gender and dominant modality. Fourteen subjects were still required for the study. The researcher personally approached individual faculty members and asked if they would complete the K.A.M.I. If their dominant modality and gender were required to complete a group, they were asked to take part in the study. In addition to the original 34 identified subjects, 28 faculty completed the K.A.M.I. Of these 28, 14 faculty met the requirement of gender and modality. These 14, plus the original 34 comprised the sample for this study.

Instruments Used in the Study

Two instruments are used in this study. The first instrument, as previously mentioned, was the 'Knowledge Accessing Modes Inventory' (K.A.M.I.) (Rancourt, 1986). This instrument was used to identify the dominant knowledge accessing mode of the problem solver. The second instrument used was a collection of

three educationally relevant selection-type, ill-defined problems constructed by the researcher.

Knowledge Accessing Modes Inventory

An individual utilizes a dominant information processing route when confronted with a learning situation (Rancourt, 1983). 'The knowledge Accessing Modes Inventory' (K.A.M.I.) (Rancourt, 1987) is designed to identify this route. Specifically, it measures three ways of knowing or 'knowledge accessing modes': 1) the noetic knowledge accessing mode is a view of reality largely determined by a commitment to personal or subjective experience as the main source of data collection and an analytical, intuitive reasoning process in determining whether the data is to be accepted as knowledge; 2) the empirical knowledge accessing mode is a view of reality largely determined by a commitment to sensory perceptions as the main source of data collection and an inductive process of reasoning in determining whether the data is to be accepted as knowledge; and 3) the rational knowledge accessing mode is a view of reality largely determined by a commitment to concepts or information currently available as the main source of data collection and a deductive process of reasoning in determining whether the data is to be accepted as knowledge (Royce, 1983).

The K.A.M.I. is composed of twenty forced choice items. These twenty items are incomplete statements; such as 'A good

teacher helps me to...', followed by three possible sentence endings to answer the statement. Each sentence ending corresponds to one of the knowledge accessing modes: noetic, empirical, or rational. The respondent is asked to rank-order the three sentence endings with first choice assigned the value 1, second choice assigned the value 2, and third choice assigned the value 3. The respondent is instructed to trust his/her first impressions and not to reflect unnecessarily. The values assigned to the sentence endings are transferred to a scoring form. This form identifies the knowledge accessing mode of the sentence endings and organizes the respondent's three choices into three columns, each representing one of the knowledge accessing modes. These columns of raw scores are totaled and converted to a score out of one hundred. The subject's highest score represents his/her dominant epistemology. The K.A.M.I. has shown test re-test (three month interval) reliability (Spearman) of 0.87 for the noetic scale, 0.71 for the empirical scale and 0.81 for the rational scale. These three scales yield a degree of association that is significant (chi square) at the 0.001 level with the three corresponding scales of Royce's Psycho-Epistemological Profile Inventory (Noble and Rancourt, 1987). Studies undertaken to determine the internal consistency of the inventory report split-half reliability coefficients of 0.82 for the noetic scale, 0.78 for the empirical scale, and 0.9 for the rational scale. Administration of the K.A.M.I. is quick, reliable, and specific to education. For these reasons, the

instrument is used in this study to classify problem solvers into six balanced groups determined by a combination of gender and knowledge accessing mode categories.

Selection-Type, Ill-Defined Problems

The second instrument used in this study is a collection of three complex, educationally relevant, selection-type, ill-defined problems constructed by the researcher. The following steps were taken to acquire these problems. First, several books focusing on ideas and controversies relating to cognitive aspects of learning, teaching strategies and styles, evaluation procedures, and disciplinary tactics were studied (Ferguson, 1980; Hamachek, 1973; Stones, 1979; Toffler, 1971; Tuma and Reif, 1980). Second, articles within educational journals elaborating on issues and problems in education were examined (Glasser, 1973; Kuhn, 1986; Phillips, 1987; Rancourt and Dionne, 1982; Simon, 1980; Snow, 1986). Third, brainstorming sessions were held with educators and students. From these sources, the following problem areas were identified: 1) selection of award winners; 2) hiring of new staff; 3) evaluation procedures; 4) learning tasks; and 5) learning methodologies.

From these identified problem areas, five selection type problems were designed. Two problems delineated the task of choosing award winners. One problem focused on choosing a staff member for an award while the other problem focused on the

selection of a student for an award. The other three problems delineated the tasks of choosing candidates to be short listed for an interview, choosing methods to evaluate student performance, and choosing assignments appropriate for learning text book material. Each problem was designed to meet the following criteria: 1) it was representative of a practical everyday problem encountered in education and was familiar to the problem solver; 2) the problem solver had to contribute to the definition of the problem from his/her own resources; 3) the problem solver had to make decisions based on his/her own knowledge and values which filled in gaps in the problem definition, or the problem solver attempted a solution to the problem before fully understanding the demands of the problem; 4) the problem was general in structure but not to the extent that it would be difficult to glean information; the problem was specific in structure but not to the extent that it would dictate the strategy to be used; 5) the problem had a sufficient number of elements allowing different options for solution; 6) the problem lent itself to the extraction of several elements relevant to the problem solver; and 7) the extraction of elements and the solution to the problem reflected individual strategies and knowledge accessing modes.

The format for the problems consisted of a main scenario delineating the problem and nine mini scenarios each offering viable solutions to the problem. The mini scenarios contained information that could be perceived by the problem solver as

being positive, negative, or inconsequential. In addition, the mini scenarios were constructed such that three reflected the noetic way of knowing, three reflected the empirical way of knowing, and three reflected the rational way of knowing. The problem solver was asked to solve the main scenario by choosing the three mini scenarios he/she felt best solved the problem and provide justification for his/her choices.

Twelve experts in the field of education (teachers, directors of education, professors of education, students of education, superintendents, guidance counsellors) were asked individually to solve the five problems. Following his/her solution, each problem solver was asked to assess each problem by responding verbally to a Semi-Directed Focused Interview (SDFI) (Appendix B). The questions within this interview reflected the criteria used for construction of the problems. The questions were open-ended, thus permitting the problem solver to identify and discuss items he/she viewed as being relevant. The purpose of this procedure was to refine the problems, to ensure face and construct validity, as well as to help select the three problems to be used in this study. These interviews were taped and analyzed. In the final analysis, three ill-defined problems were selected: 1) the 'Task Problem'; 2) the 'Interview Problem'; and 3) the teacher 'Award Problem'. The experts indicated that these three problems were the most representative of problems encountered in education. Furthermore, they were of interest to the target sample and met the construction requirements

articulated in the SDFI. A description of the three problems follows.

The Task Problem

Consciously or unconsciously, everyone knows what is required to learn text book material. Teachers who recognize that everyone learns such material differently may opt to present classes with a number of different tasks designed to help the student learn the material. The 'Task Problem' addresses the problem of choosing learning tasks.

Specifically, the problem solver is asked to assume the role of a teacher registered in a curriculum design course for adult education at the local university. The course lasts for one semester (thirteen weeks) and scheduled for one night per week for three hours. On successful completion of the course, the teacher receives an increase in salary and a possible promotion. On the first night of the course, the professor distributes the course outline accompanied by a sheet of paper describing nine learning tasks. These nine learning tasks include such activities as writing a text book review, writing chapter summaries, designing a poster presentation, or writing a reaction paper. Each learning task described, contains information the teacher may perceive as being positive, negative, or inconsequential. In addition, three of the learning tasks reflect the noetic way of knowing, three reflect the empirical

way of knowing, and three reflect the rational way of knowing. Furthermore, the professor announces that one text book is required (approximately three hundred and fifty pages, ten chapters). It is well organized and contains current content, integrating principles with application. The professor explains that the final evaluation for the course is based on the completion of three learning tasks. The teacher is faced with the problem of choosing and justifying the selection of three learning tasks from the list of nine learning tasks distributed. This must be done immediately. This is the only information provided by the professor.

This problem in its entirety is presented in Appendix A. The problem was presented to the problem solver in the same format as presented in the appendix with the exclusion of the knowledge accessing mode found in parentheses following each mini scenario.

The Interview Problem

There are numerous problems in education that are encountered in the classroom, however, there are also inescapable problems existing within the bureaucracy. One of these problems arises when the hiring of new staff members is required. The 'Interview Problem' addresses the issue of hiring staff but also focuses on teaching methodologies. Many educators recognize that people have preferences and indeed may learn more efficiently

from one teaching method as opposed to another. It is assumed that schools are interested in hiring as many teachers with different teaching methodologies as possible. The problem is to decide which three teachers should be interviewed.

Specifically, the problem solver is asked to assume the role of a member on a hiring committee to help select three candidates from nine to be interviewed for one full time position available in the school. The school requires someone to teach a variety of subjects offered as part of the social science curriculum. The school's main concern is to hire a teacher possessing a distinct teaching style. The nine applicants chosen for the short list were selected by the administrator based on a completed application form, two letters of reference outlining the candidate's teaching method, and intuition that the candidate would be an asset to the school. Content from each of the candidate's dossiers was summarized. Information in these summaries included such things as age, gender, ethnic background, former teaching experience, and method of evaluating student performance. In addition three of the summaries reflect the noetic way of knowing, three reflect the empirical way of knowing, and three reflect the rational way of knowing. The only information available to the hiring committee was the dossier summaries of each candidate. Each summary contains information that committee members may perceive as being positive, negative or inconsequential. Administration would like to interview all nine candidates'; however, due to time restrictions, this cannot

be accomplished. The hiring committee has time to interview only three people. The problem solver must decide which three candidates should be interviewed and defend his/her choice to the committee. This is the only information available.

This problem in its entirety is presented in Appendix A. The problem was presented to the problem solver in the same format as presented in the appendix with the exclusion of the knowledge accessing mode found in parentheses following each mini scenario.

The Award Problem

A common problem facing both students and faculty at year end involves selecting award winners. Usually the criteria for these awards are subjective. This last problem deals with the issue of selecting a worthy candidate for an award.

Specifically, the problem solver is asked to assume the role of a member on the Board of Governors of a local post secondary institution. At the termination of each year, the board chooses three teachers to receive an 'Outstanding Teacher' award. The criteria for selection are not clearly defined; however, the purpose of the award is to recognize three teachers' unselfish contributions to teaching and the school environment. In a general discussion, several important characteristics required by the recipients were discussed: honesty, trustworthiness, enthusiasm, effectiveness as a teacher, involvement in

extracurricular activities, willingness to help others, genuineness, as well as positive attitude. The problem solver has been asked to be a member of the selection committee to help decide which three teachers should receive the awards for this year. The choice has been narrowed to nine candidates. Contributions made to the school and personal information regarding each of the nine candidates have been distributed. These summaries include such things as age, gender, years of service to the school, contributions to the school and the community. In addition, three summaries reflect the noetic way of knowing, three reflect the empirical way of knowing, and three reflect the rational way of knowing. Some of the information contained in these summaries may be perceived by the problem solver as being positive, negative, or inconsequential. This is the only information available. The problem solver must select three candidates and defend his/her selection to the committee.

This problem in its entirety is presented in Appendix A. The problem was presented to the problem solver in the same format as presented in the appendix with the exclusion of the knowledge accessing mode found in parentheses following each mini scenario.

Research Procedures

The Knowledge Accessing Modes Inventory (K.A.M.I.) (Rancourt, 1987) was administered to a number of subjects to ensure three groups of sixteen subjects, with each group representing one of the three dominant knowledge accessing modes: noetic, empirical, and rational and each group balanced with regards to gender. These forty-eight subjects were the problem solvers for this study.

At an agreed-upon time and place, each problem solver met with the researcher. Care was taken to ensure privacy. During this allotted time, the problem solver solved a practice problem as well as the three selection-type, ill-defined problems chosen for the study.

Before presentation, the experimenter explained to each subject that the present research was designed to study the processes and patterns people exhibit as they solve complex ill-defined problems. It was explained that the problem solver would be required to make a choice among several options. Furthermore, it was emphasized that what was important was the how and why of what was being done. Each problem solver was instructed to state out-loud everything he/she was thinking while engaged in the execution of the task.

A three ring binder was placed in front of each problem solver. On the first page was a practice problem to familiarize the subject with the thinking out-loud technique (Appendix C).

The problem solver was instructed to read the problem out loud. After reading this problem, the majority of problem solvers requested pencil and paper. This was not encouraged; but if requested, they were provided for the problem solver. He/she was reminded to verbalize everything he/she recorded on the paper. The experimenter answered questions and reminded the problem solver to keep talking. These practice trials were taped.

After completing the practice problem, the problem solver was instructed to turn the page. The problem solver was faced with either the 'Task Problem' or the 'Interview Problem' (presented in the same format as in Appendix A with the exclusion of the knowledge accessing mode appearing in parentheses following each mini scenario). Presentation of the 'Task Problem' and the 'Interview Problem' was randomized, but the 'Award Problem' remained as the final problem to be solved by all problem solvers. It was felt that if fatigue set-in, it would surface in the last problem and be readily recognized. If fatigue became a problem, the 'Award Problem ' could then be deleted from the study or analyzed with the appropriate acknowledgement to the fatigue factor.

Once again, the problem solver was instructed to read the problem out loud and to solve the problem however he/she wished. This pattern was repeated until the three problems had been solved. The verbalized solutions (protocols) to the problems were taped. As the problem solver was solving each problem, the researcher was taking notes and reminding the problem solver to

keep verbalizing. In all, there were 144 protocols collected (forty-eight problem solvers solving three problems each). These 144 protocols were transcribed such that each statement articulated by the problem solver was kept together in a sequence of lines.

Research Design

In summary, the sample for this study consisted of 48 in-service, post-secondary teachers (six groups determined by a combination of gender and knowledge accessing mode catagories). These 48 subjects were instructed to solve out-loud three complex, educationally relevant, selection-type, ill-defined problems. The presentation of the first two problems was randomized with the third problem being the same for all problem solvers. Each subject's verbalizations were taped and transcribed verbatim to enable each sentence to be chronologically numbered (see Appendix D). The protocols were analyzed by dividing each protocol into blocks of activities such that the solution path for the problem solver progressed from one block of mental activity to the next. Each block of activity was timed. A coding grid, based on content analysis of the protocols, was designed to categorize the statements or collection of statements articulated by the problem solver.

Descriptive statistics, chi-square tests, multivariate and univariate analysis of variance were performed on the data. The

adopted level of significance was 0.05. The purpose of these tests was to determine the existence or nonexistence of associations between 1) steps required to solve the problems and category of problem solver, steps and gender, steps and knowledge accessing mode; 2) time required to solve the problems and category of problem, time and gender, and time and knowledge accessing mode; 3) criteria introduced to the problem definition and knowledge accessing mode, criteria introduced and gender; 4) strategies selected to solve the problems and knowledge accessing mode; and 5) final solutions and knowledge accessing mode.

As a result of the above analyses, a global profile of the problem solving behaviours for problem solvers in this study was established. The variables in this profile included: 1) the time and time patterns required to solve the problems; 2) the number of steps and step patterns required; 3) the strategy and strategy patterns selected; 4) the criteria introduced to define the problem further and the introduction patterns; and 5) the final selection and selection patterns.

CHAPTER IV

PREPARATION OF DATA FOR ANALYSIS

Forty-eight subjects (balanced in regards to gender and dominant knowledge accessing mode - noetic, empirical, rational) were asked to solve three complex, educationally relevant, selection-type, ill-defined problems. Despite the varied content of each problem, the problem structure was identical.

A main scenario which introduced each problem was followed by nine mini scenarios. Three of the nine mini scenarios represented the 'noetic' way of knowing; three represented the 'empirical' way of knowing; while three represented the 'rational' way of knowing. The problem solver was asked to solve the problem explained in the main scenario by selecting three mini scenarios. Each problem solver was instructed to read the main scenario plus the nine mini scenarios out-loud and verbalize all thoughts that transpired as a result. The 'how' and 'why' the problem solver proceeded as he/she did was crucial and was the focus of this study. These verbalizations were taped and transcribed verbatim. The total number of protocols collected was 144 (48 subjects, three problems per subject). The following chapter describes how the protocols were arranged to facilitate analysis.

Organization of the Protocols

To prepare the protocols for analysis, two procedures were executed. The first procedure divided the protocols into blocks of activities such that the solution path for the problem solver progressed from one block of mental activity to the next. These blocks of activities were called 'steps' and each of these steps was timed. The second procedure for organizing the protocols involved designing a coding grid, based on content analysis of the protocols, to categorize the statements or collection of statements articulated by the problem solver.

Dividing Protocols into Steps

For the purpose of analyzing the protocols, each protocol was broken into blocks of activities or unified sequences of mental activity. Between the blocks of activity, a transition, or passage from one consideration to another was evidenced. The term 'step' was applied to the mental activity that transpired within each block of activity. The mechanical cues within each step, combined with cues inherent in the protocol, indicated a transition in mental activity and were used to divide each protocol into steps. An example of a protocol divided into steps is found in Appendix D. As seen in this example and for all protocols, 'Step 1' represented the reading of the main scenario and any follow-up comments to that reading; 'Step 2' was the

reading of the nine mini scenarios regardless of the number of times a problem solver referred back to previously read mini scenarios; while 'Step 3' and subsequent steps represented the solution to the problem, a second review of preferred mini scenarios or a unified sequence of mental activity such as rereading the main scenario or restating the task to be performed. In extreme cases, a problem solver could solve a problem in two steps. Problem solvers in this study, however, required a minimum of three steps before obtaining a solution while some problem solvers required as many as six steps. The total number of steps required to solve a problem was dependent upon the number of transitions in mental activity. Appendix F displays in table format the total number of steps required by each problem solver to solve each problem.

The division of each protocol into steps was validated by an outside examiner. Of the 144 protocols collected, the outside examiner and the researcher agreed on the division into steps, of 133 of the protocols (92%). The eleven questionable protocols were reassessed by the researcher and the outside examiner, and agreement on the final division was unanimous.

In addition to dividing each protocol into steps, each step was timed. The number of steps and the time (expressed in minutes) required to solve each step of each problem by the three categories of problem solvers is displayed in table format in Appendix E, while Appendix G displays the total time required by each problem solver to solve each problem.

Designing the Coding Grid

The next procedure in organizing the protocols involved establishing a method for categorizing each statement or collection of statements articulated by a problem solver. Since an already made structure did not exist in the literature, the researcher had to devise a structure based on content analysis of the protocols. Each statement articulated by each problem solver was carefully scrutinized. Through a process of categorization of statements combined with the examination of mechanical aspects of each protocol a structure emerged. This structure became the coding grid for the protocols.

The first two codes 'Read Problem' and 'Read Problem in Segments' described the mechanics of reading the main scenario. Likewise the codes 'Considered a Mini Scenario' and 'Addressed a Mini Scenario' described the mechanics of internalising the mini scenarios. But, by definition, each step included all statements made during or after the reading of the main scenario or mini scenarios. These statements fell into the following catagories: planning statements (example: "I'm going to make three categories. Category one is for candidates I like; category two is for possible candidates; category three is for candidates I don't like. I'm going to read each mini scenario and categorize each candidate into a group."); restating task statements (example: "Let me go back. Now, what is it I am suppose to do? Oh yes, choose three candidates to be interviewed for a teaching

position in the social science department."); observation statements (example: "Outstanding Teacher Award, I don't agree with that right off the bat. Oh well, I guess I'll go along with the exercise."); positive and negative appraisal statements (example: "Oh, I like her; she is dynamic. I'll keep her in mind." "I don't like him; he seems to be too structured, but I'll wait and see what the other candidates are like."); adding personal criteria statements (example: "I don't like any of this criteria, I'm going to pick my candidate based on their effectiveness as a teacher."); statements highlighting information found in the problem (example: "This person has contributed to the school environment. That was one of the criteria listed above."); and decision statements to include or exclude a mini scenario (example: "I'm going to keep this person because..." "I want to eliminate this person because..."). The coding grid and a description of the codes is found in Table 1.

One code, the 'Highlighted Criteria' code found in the coding grid requires special explanation. Within the main scenario of each problem certain details emerge as significant. For example, the details that stand out in the 'Task Problem' are course length and text book; in the 'Interview Problem', teaching requirements and style; and in the 'Award Problem', the teachers contribution to teaching and the community. Table 2 describes in detail the possible highlights from the main scenario for each problem. The significance of these highlights will become clear when discussing the criteria a problem solver introduces or contributes to the definition of the problem.

Table 1

Coding Grid for Categorizing Statements Articulated in Protocols

Code	Description
Read Problem	- read main scenario from start to finish without stopping
Read Problem in Segments	- started to read main scenario, paused, articulated a statement reflecting the material just read
Restated Task	- a statement restating what was required
Planning Statement	- a statement indicating a plan for solution
Observation Statement	- a statement clarifying, questioning, summarizing, commenting on the content of the main or mini scenario(s)
Highlighted Criteria	- a statement which highlighted criteria found in the main scenario
Considered a Mini Scenario	- consideration of a mini scenario by reading or glancing through the mini scenario
Addressed a Mini Scenario	- comments articulated after considering a mini scenario
Positive Appraisal	- a statement indicating a favorable evaluation of the mini scenario
Negative Appraisal	- a statement indicating an unfavorable evaluation of the mini scenario
Added Criterion	- a statement indicating the problem solver added personal criterion to be used to solve the problem
Restated Added Criterion	- a statement restating the personal criterion added
Excluded a Mini Scenario	- a statement indicating the decision to exclude a mini scenario
Included a Mini Scenario	- a statement indicating the decision to include a mini scenario

Table 2

Highlights from the Main Scenario
of Each Problem

Task Problem:	
	Highlight 1 -length of course, one semester (thirteen weeks) one night per week, for three hours
	Highlight 2 -length of text book, three hundred and fifty pages, divided into ten chapters
Interview Problem:	
	Highlight 1 -the school wanted to hire a 'generalist' to teach a variety of subjects
	Highlight 2 -the variety of subjects to be taught were part of the Social Science curriculum
	Highlight 3 -the school wanted a teacher with a distinct teaching style
	Highlight 4 -the school wanted a teacher who would be an asset to the school
Award Problem:	
	Highlight 1 -the award was called the 'Outstanding Teacher Award'
	Highlight 2 -this award was established to recognize a teacher's unselfish contributions to teaching
	Highlight 3 -this award was established to recognize a teacher's unselfish contributions to the school environment (extracurricular activities)
	Highlight 4 -this award was established to recognize a teacher who was honest, trustworthy, enthusiastic, willing to help others, genuine, possessed a positive attitude, and considerate
	Highlight 5 -this award was established to recognize an effective teacher

An example of a transcribed and scored protocol is found in Appendix D. The problem solver, here, is female and scored 'rational' on the 'Knowledge Accessing Modes Inventory' (K.A.M.I.). In the 'Interview Problem', the problem solver was asked to select three candidates from nine to be interviewed for a full time teaching position within the social science department. The hiring committee was looking for a teacher who could teach a variety of social science subjects but possessed a distinct teaching style.

Lines 1 to 29 comprised the first step toward the solution of the problem. During this step, the problem solver articulated a planning statement (Line 1: "Ok, I'll read the problem through."), then read the main scenario from start to finish without stopping. After reading the main scenario, she restated the task, made an observation about the required task and articulated another planning statement.

Lines 30 to 120 comprised the second step toward the solution of the problem. This entire step involved reading each mini scenario. No comments reflecting the content of the scenarios were articulated. After reading all nine scenarios, four observation statements concerning the problem were articulated.

Lines 121 to 256 comprised the third step toward the solution of the problem. Again, at the beginning, a planning statement was articulated (Line 121: "So I guess I'm going to look at each candidate to see what I think."). Each mini

scenario was reread, and the problem solver addressed the scenario by commenting on its content. Some of these comments indicated that: 1) criterion had been added (Line 146: "I think age is important to consider."); 2) the problem solver felt positive about a candidate (Line 148: "He may be ok; I may consider him."); 3) the problem solver felt negative about a candidate (Line 179 and 180: "Well, I'm not too keen on the notes. I can picture some of my teachers who were note writers, and sure it gave me something to do during class, but, I ask you, at this age?"); and 4) a candidate had been selected for an interview (Line 163: "I would like to interview her."). In Step 3, the problem solver also restated the task to be accomplished and made observation statements.

Lines 257 to 266 comprised the fourth step toward a solution of the problem. In this step, the final selections were made. From the protocol, it was apparent that the first two choices were made quickly. One was based on the added criterion, age (Line 257: Well, I think I will go for youth, number 1.") while the other candidate was selected for generating ideas (Line 258: "I'll take number 2 for generating ideas."). The third choice, however, was more difficult. The candidate chosen reflected what the problem solver personally liked (Lines 263 to 264: "I like the idea of making students think. I think I will choose 4 over 8.").

To validate the accuracy and reliability of the scoring grid, four outside readers involved in education and in

supervisory capacities (two program coordinators, one department head and one program head) were given nine protocols and asked, individually, to score these nine protocols. The four outside readers were divided into Group A and Group B, both groups were comprised of a reader who had taken part in the study, a reader who had no affiliation with the study, and the researcher as an impartial member. Group A had one set of nine protocols while Group B comprised another set of nine protocols. As previously stated, the study consisted of three groups of problem solvers (balanced with regards to gender and dominant K.A.M.), with each problem solver solving three problems. The protocols the readers were asked to score were randomly selected such that all combinations were recognized. Hence, a total of eighteen protocols were selected. The outside readers were given a copy of each problem, a copy of the grid (see Table 1), a copy of the highlights from the main scenario of each problem (see Table 2), a copy of a scored protocol (different from the protocols in their package), and nine protocols already divided into steps. Their instructions were 1) to read a line of the protocol and score the line with the appropriate code; 2) to react spontaneously to the line; and 3) if an appropriate code was not obvious, to place a question mark beside that line.

The degree of agreement among the outside readers and the researcher (as one of the group members) on the coding grid was calculated by looking at the percentage of matches (the number of agreements out of the total). The total agreement percentage was

calculated at 70% (361 codes used, 252 codes were in agreement) while the percentage of two or three people in agreement was calculated to be 83% (361 codes used, 301 were in agreement).

Specifically, three codes appeared to be ambiguous: 1) highlighted Statements (see Tables 1 and 2); 2) added criteria (see Table 1); and 3) positive or negative reactions (see Table 1). The coding grid was reworded to accommodate the suggestions made by the outside readers. Once these codes were explained and reworded, the ambiguity disappeared. The purpose of the outside readers was to check for accuracy as well as reliability of the coding grid.

To capture the unique way each problem solver approached and solved a problem, the division of each protocol into steps and the codes generated in each step is recorded in table format in Appendix K. Specifically, the tables are arranged according to gender and dominant knowledge accessing mode of the problem solver. The problem solver's identification number is displayed across the top of the table while information concerning how the problem solver solved the problem is made available in the vertical columns. This information includes 1) the strategy used to solve the problem (to be explained later); 2) the number of steps required to solve the problem; 3) the type of statements articulated in each step (according to the coding grid); and 4) the number of times each type of statement was articulated in a step. These tables provide a microscopic picture of what transpired within each protocol and within each group of protocols.

For example, the noetic male problem solver (identification number 41) while solving the 'Task Problem' used solution Strategy A (to be explained later) to solve the problem. In 'Step 1', he read the main scenario from start to finish without stopping and did not engage in any further mental activity. In 'Step 2', he read the nine mini scenarios and articulated one observation statement. In 'Step 3', he solved the problem by adding personal criteria to the problem definition and selected three mini scenarios.

Identifying Strategies for Solution

Once the protocols were divided into steps of solution, each step timed, each line or group of lines from each protocol categorized and the codes recorded on summary tables, strategies for solving the problems were identified. Since so many problem solvers were able to solve the problems in three or four steps (91%), it seemed appropriate to identify the strategy in relation to the mental activity displayed in Step 2. Hence, the problem solvers fell into one of three different strategies: A) those who reviewed all elements of the problem before attempting a solution to the problem; B) those who addressed some elements of the problem; and C) those who attempted a solution to the problem before all elements were reviewed by C.1) making definite decisions to include mini scenarios; C.2) making definite decisions to exclude mini scenarios; and C.3) making definite

decisions to include and to exclude mini scenarios. Table 3 describes in detail these different strategies.

In summary, each protocol was divided into steps and each step timed. Statements or collections of statements in each protocol were categorized using a coding grid based on content analysis of the protocols. Five strategies of solution were identified in relation to the mental activity displayed in Step 2. These procedures prepared the data for analysis. Descriptive statistics, chi-square tests, multivariate and univariate analysis were performed on the data. The adopted level of significance was 0.05.

Table 3

Strategies for Solving
Selection-Type, Ill-Defined Problems

Strategy A: All Elements Reviewed Strategy

Description: The problem solver reviewed all elements of the problem before attempting a solution to the problem.

Strategy B: Elements Addressed Strategy

Description: As the problem solver reviewed the elements of the problem, elements were addressed.

Strategy C: Immediate Solution Strategies

Description: The problem solver attempted a solution to the problem before all elements were reviewed by

C.1: Making Decisions to Include Only Strategy

Description: The problem solver attempted a solution to the problem by making a definite decision to include elements.

C.2: Making Decisions to Exclude Only Strategy

Description: The problem solver attempted a solution to the problem by making a definite decision to exclude elements.

C.3: Making Decisions to Include and to Exclude Strategy

Description: The problem solver attempted a solution to the problem by making a definite decision to include and to exclude elements.

CHAPTER V

PRESENTATION AND INTERPRETATION OF FINDINGS

The present research was designed to explore the processes and patterns that developed as individuals solved complex, educationally relevant, selection-type, ill-defined problems. From this macroscopic objective emerged four microscopic objectives focusing on the coordination of the cognitive processes and patterns. These objectives were 1) to determine the criteria an individual introduced or contributed to the definition of the problem; 2) to determine how an individual integrated the above criteria; 3) to determine the patterns and solution strategies that were used to solve the problem; and 4) to determine if there was a relationship between an individual's problem solving behaviour and his/her dominant knowledge accessing mode. These problem solving behaviours refer to strategies, solution patterns, selection and introduction of criteria, and final solution.

In this chapter the findings are explained in relation to the above objectives. To do so, the chapter is divided into two sections. The first section provides a general discussion of the solution patterns of the problem solvers. Topics include the information processing system, limitations of short term memory, and the inherent difficulty of the three problems used in the study. In the second section the solution patterns are discussed, specifically. Topics include the number of steps and

time required to solve the problems, the introduction or contribution of criteria to the problem definitions, the strategies used to solve the problems, and the actual solutions to the problems.

Solution Patterns, General

Simon (1978) suggested it was sufficient to assume that apart from the sensory organs the information processing system operated serially, one process at a time. He assumed that the problem solver moved along a solution path until the goal state was achieved. The solution patterns of the problem solvers in this study supported this assumption. Although the evidence was not conclusive, the findings indicated that this, indeed, happened.

All problem solvers in the study took at least three steps to solve the problems, while others required as many as six steps, despite the fact that it was possible to solve the problems in two steps (see Appendix F). In each situation, the problem solvers progressed from one unit of mental activity to the next in a series of steps until the problem was solved.

Simon (1973) also postulated that ill-defined problems eventually became a series of well-defined problems for the problem solver. Indirectly, the present research investigated whether a problem solver represented selection-type, ill-defined problems by selecting elements from the problem and representing

such elements as a well-defined problem. The problem solver then obtained a solution to this well-defined problem. Once again, the findings indicated that this did occur. First, Strategies A and B, which involved reviewing all elements of the problem before attempting a solution comprised the two strategies most frequently used to solve the problems (see Appendix H). Second, many problem solvers introduced criteria to the problem definition (see Appendix K). In most cases, these criteria were introduced once the elements of the problem had been reviewed. Third, verbalizations of the problem solvers indicated that the problem was viewed as a well-defined problem. For example, one particular problem solver (ID: 47, rational male, where 'ID' refers to the problem solvers identification number) read through all elements of the 'Task Problem' and then said:

> I am working this on the basis of what would help me best to get this course. I am looking at this as a student. I am very motivated because it means either a promotion or salary raise. So, to master the material; also I want to learn the material; I'm interested in; and since I'm going to be learning this on my own; I took number 1. Writing chapter summaries is one way of definitely learning the material. If I chewed up the book, I should be able to get something on research projects. So, I will take number 6, the research projects. As my third choice, number 9, implications, they should be fairly straight forward.

In another example, a problem solver (ID: 20, empirical female) read the main scenario of the 'Interview Problem' without stopping and then said:

> Ok, so we are looking for a teacher possessing a distinct teaching style. I guess one question I might ask is whether that is the department's wish to look for someone with a distinct teaching style or whether it is the administrations wish. I'll assume that it is the departments wish as well. I'll assume there is a consensus around that.

As this problem solver read each mini scenario, she assessed each candidate on the basis of whether he/she possessed a distinct teaching style. She summarized her initial review of the mini scenarios by saying:

> Ok, well on the first reading through, I've eliminated candidates 3 and 1 because their teaching method was not a distinct style. I'm going to eliminate number 7 because she sees herself only as a resource person. Students answer personally to her. That would be impractical in teaching larger classes and that is our requirement; I'll assume that. So if we are going to interview three; we have nine, so we are down to 6. So I have to eliminate 3.

The problem solver reconsidered the six remaining candidates on the basis of a distinct teaching style. She did, however, introduce age, gender, and ethnic background factors as criteria.

> I was just looking between number 4 and 6; looking at the age factor and the European, British factor, and trying to ask myself if those factors made any difference or not. When we are looking for a distinct teaching style, I assume other factors have to come into play. The European speaks with an English accent and we would only know if we interviewed him whether or not that would be a deterrent for the students or not.
>
> Number 5 is a young female English Canadian with references Number 6 would be a male, a bit older.

Her final selection was based on the gender of the candidate, age, ethnic background, and the possession of a distinct teaching style.

> So, I think I would go with 5,6, and 8. That would give us two females and one male. We are looking at some variety there. All three are on the younger end of the scale, which I think is important.
>
> One is English Canadian, so English would be no problem. One is British, we could find out in the interview whether English was a problem or not. In the last one, it doesn't say anything about language. So, I assume that is not a problem one way or another. So, I think if we looked at those three candidates, we would not only have a variety of people, but, they would all be towards the young end. We would have two females and one male which would give some variety; and we are looking at different methods than we generally use in this school. So, certainly they fulfill the requirement of having distinct teaching styles.

In the next example, the problem solver (ID: 48, noetic male) read through the main scenario and the nine mini scenarios of the 'Award Problem' without stopping. He quickly said:

> I'm going to base my decision on age, retirement, and compassionate reasons. So, I took the two retiring people and the guy who was dying. There wasn't enough difference in all their accomplishments. Nothing stood out bigger in all their accomplishments, other than the fact that two were retiring and one had the terminal disease.

In all three examples, the problem solvers selected elements from the ill-defined problem and represented these elements as a well-defined problem.

This study also postulated that the movement along a solution path was constrained by one's limitations of the short-term memory. The problem solvers were aware of these constraints and used paper and pencil supplied by the researcher to record

key concepts contained in the problem. Some problem solvers 'chunked' the information contained in the problem by establishing three or four global classifications and then assigning mini scenarios to the various categories.

In the first example, the problem solver (ID: 3, rational female) categorized the candidates outlined in the 'Interview Problem' into three different groups.

> I've got three little lines here. I always work with pen and paper. The first group is 'yes'. The second group in the middle is 'ok'. The third group is the ones I definitely don't want, 'no'. When I get them all sorted, I would then go back and forth and knock them out.

The 'Award Problem', particularly illustrated the limitations of one's short-term memory. The main scenario of the problem comprised a list of characteristics required by the candidate in order to receive the award. To remember such details, some problem solvers initiated a written account of the details. For example:

> I'm going to write these down; I'll never remember them all (ID: 11, empirical male).

Others grouped the list under a general heading such as 'humanistic qualities'. For example:

> Ok, we've got teaching effectiveness, extracurricular activities, and let me call them good quality characteristics (ID: 35, rational female).

Others selected only certain characteristics perceived as being important. For example:

> I can't remember all of these. I'm going to make my selection based on the candidates effectiveness as a teacher (ID: 10, noetic female).

Difficulty of the Problems

The three problems constructed for this study varied in difficulty. This was not intentional, but the 'Task Problem' and the 'Award Problem' were easier to solve. This was evidenced in the steps and time required to solve these problems.

In regards to steps, fewer problem solvers were able to solve the 'Interview Problem' in three steps (see Appendix F). Specifically, of the forty-eight problem solvers, thirty-five (79%) solved the 'Task Problem' in three steps; thirty-three (69%) solved the 'Award Problem' in three steps; only twenty-four (50%) were able to solve the 'Interview Problem' in three steps.

In regards to time, problem solvers in the present study took longer to solve the 'Interview problem' (see Appendix G). Specifically, the average time required to solve the 'Task Problem' was 13.1 minutes; to solve the 'Award Problem', 13.8 minutes; and to solve the 'Interview Problem', 19.5 minutes.

In addition, considering the 'Task Problem', teachers are familiar with preparing various types of assignments. Since they have progressed through the educational system themselves, they have learned what they like to do as well as what they are good at doing. In this problem, problem solvers assumed they knew what the task entailed from reading the main heading of each mini scenario. (The old adage 'familiarity breeds contempt' seemed to be true.) The problem solvers' extensive knowledge base and familiarity with problem content may account for the ease in

which this problem was solved. The 'Award Problem' was the last problem solved by all problem solvers. By this time, problem solvers were familiar with the problem structure. Again, familiarity, specifically with the problem structure, may account for the ease with which this problem was solved. The 'Interview Problem', on the other hand, focused on the hiring of new staff members. In the educational milieu this is taken seriously. Perhaps the problem solvers, being teachers, felt more committed to this task than the other two tasks.

Solution Patterns, Specific

The information in the following tables has been extracted from the protocol summary tables found in Appendix K, as well as the tables found in Appendices E, F, G, H, I, J. As a reminder, six categories of problem solvers, balanced in regards to gender and dominant knowledge accessing mode comprised this study. There were eight problem solvers in each category and each was required to solve three problems. Hence, three protocols were collected from each problem solver, making 144 protocols collected in all.

Also, as a reminder, the presentation of the 'Task Problem' and the 'Interview Problem' was randomized, with the 'Award Problem' remaining as the final problem to be solved by all problem solvers. It was felt that if fatigue set-in, it would surface in the last problem and be readily recognized.

Steps and Time Required to Solve the Problems

Table 4 is arranged to display the frequency of protocols collected from each category of problem solver and the steps required to solve a set of three problems. As seen from this table, the majority of problem solvers in the present study required three steps to solve the problem. Specifically, ninety-two protocols from one hundred forty-four collected (64%) were solved in three steps. Fifty-two protocols (36%) were solved in more than three steps (four, five, or six steps).

With four, five, and six steps regrouped in one category, chi-square tests were performed to determine if an association existed between categories of steps and categories of problem solvers, or categories of steps and gender. At the 0.05 level of significance, no pattern was found to indicate an association between the number of steps required to solve the three problems and the category of problem solver (for males: chi-square = 0.128, df = 2, p = 0.938; for females: chi-square = 1.848, df = 2, p = 0.600). Nor was an association found between the number of steps and dominant knowledge accessing mode (gender specific) (chi-square = 1.084, df = 1, p = 0.298).

Table 5 displays the frequency of problem solvers within each category of problem solver in relation to the pattern of steps required to solve each problem regardless of the order of presentation. For example, the '3 - 3 - 3' pattern indicates that the problem solver solved each of his/her problems in three

Table 4

Frequency of Protocols Collected*
from Each Category of Problem Solver
and the Steps Required to Solve
a Set of Three Problems

Steps Required	Dominant Knowledge Accessing Mode: Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
3 Steps	16	13	16	13	17	17	92
4 Steps	4	11	6	7	7	4	39
5 Steps	1	-	2	3	-	3	9
6 Steps	3	-	-	1	-	-	4
Total	24	24	24	24	24	24	144

*24 protocols collected (8 problem solvers per category, each problem solver solving 3 problems).

Note: With steps 4, 5, and 6 regrouped into one category:

1) chi-square (steps, male categories) = 0.128, df = 2, p = 0.938;

2) chi-square (steps, female categories) = 1.848, df = 2, p = 0.600;

3) chi-square (steps, gender) = 1.084, df = 1**, p = 0.298.

**When df = 1, Yates' Correction for Continuity is used.

Table 5

Frequency of Problem Solvers*
in Relation to the Pattern of Steps Required
to Solve the Problems

Pattern of Steps	Dominant Knowledge Accessing Mode: Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
Same # of Steps Required for Problem Sequence 1, 2, 3**							
3 - 3 - 3	3	1	3	2	4	3	16
4 - 4 - 4	-	-	-	-	1	-	1
6 - 6 - 6	1	-	-	-	-	-	1
Decreasing # of Steps Required for Problem Sequence 1, 2, 3							
5 - 4 - 4	-	-	1	-	-	-	1
5 - 3 - 3	1	-	-	-	-	2	3
5 - 4 - 3	-	-	1	1	-	1	3
4 - 4 - 3	1	2	-	1	1	1	6
4 - 3 - 3	1	1	1	-	2	1	6
Increasing # of Steps Required for Problem Sequence 1, 2, 3							
3 - 4 - 6	-	-	-	1	-	-	1
3 - 4 - 5	-	-	-	1	-	-	1
3 - 4 - 4	-	1	-	-	-	-	1
3 - 3 - 4	1	1	1	1	-	-	4
Varied # of Steps Required for Problem Sequence 1, 2, 3							
4 - 5 - 3	-	-	-	1	-	-	1
4 - 3 - 4	-	1	-	-	-	-	1
3 - 4 - 3	-	1	1	-	-	-	2
Total	8	8	8	8	8	8	48

*8 problem solvers per category.

**Problem Sequence 1, 2, 3 refers to the first problem solved, second problem solved, third problem solved.

steps. Whereas the '4 - 5 - 3' pattern indicates that the problem solver took four steps to solve his/her first problem, five steps for the second, and three steps for the third.

As seen from this table, eighteen of the forty-eight problem solvers (37%) took the same number of steps to solve each of their three problems. Nineteen (40%) displayed a decreasing pattern in the number of steps required to solve their problems; seven (15%) displayed and increasing pattern in the number of steps required; while four (8%) displayed a varying pattern in the number of steps required.

As previously indicated, each step of each protocol was timed (see Appendices E and G). Step 1 absorbed the reading of the main scenario and any follow up comments to that reading. Regardless of the problem, this step was completed in approximately 2.0 minutes. In most cases, a reading of more than 2.0 minutes indicated that the problem solver read through the main scenario pensively, read the main scenario in segments, articulated comments while reading the main scenario, or read the main scenario more than once. It was assumed that the longer it took a problem solver to internalize the main scenario, the more he/she understood the task to be performed. The 'Award Problem' was the last problem solved by all problem solvers. For this problem, Step 1 was completed slightly faster because many problem solvers read the main scenario to the end of characteristics and said:

> Ok, the problem is the same as the other two, three out of nine and justify (ID: 25, noetic female).

Step 2, by definition, represented the reading of the nine mini scenarios, any comments made during this reading and any return to previously read mini scenarios for the purpose of comparison or reconsideration. Here, the problem solvers can be divided into two groups: 1) those who read the nine mini scenarios without making comments; as opposed to 2) those who commented throughout the reading of the nine mini scenarios or returned to previously read mini scenarios. The amount of time required to read through the mini scenarios (without commenting) for the 'Interview Problem' was approximately 6.0 minutes. For the 'Task Problem' and the 'Award Problem', it took approximately 5.0 minutes (see Appendix E). If a problem solver took less than these approximate times to complete Step 2, this generally indicated that the problem solver had glanced through the mini scenarios as opposed to reading them in their entirety. If a problem solver took more than these average times to complete Step 2, this indicated that the problem solver read through the mini scenarios pensively, commented on all or several mini scenarios, or referred back to previously read mini scenarios.

Step 3, and subsequent steps, by definition, involved either the solution to the problem, a review of preferred mini scenarios, a unified sequence of mental activity such as rereading the main scenario, or restating the task to be accomplished. The time spent in each of these steps varied extensively (1.0 to 17.7 minutes). The number of mini scenarios reviewed or the number of mini scenarios compared or contrasted

accounted for this variation.

Table 6 displays the frequency of protocols collected from each category of problem solver as well as the intervals of time required to solve a set of three problems. In the present study thirty-five protocols from one hundred forty-four collected (24%) were solved in five to ten minutes. Forty-four (31%) were solved in ten to fifteen minutes, while sixty-five (45%) required more than fifteen minutes to solve.

With the time intervals dichotomized into two categories, fifteen minutes or less and larger than fifteen minutes (these dichotomized categories closely reflect the median split displayed in the frequency distribution in Table 6 and the mean time of 15.5 minutes), chi-square tests were performed to determine if an association existed between intervals of time and categories of problem solvers, intervals of time and gender, or intervals of time and dominant knowledge accessing mode. At the 0.05 level of significance, the association between time and category of problem solver was not significant (chi-square = 10.57, df = 5, p = 0.061). Nor was the association between time and gender significant at the 0.05 level of significance (chi-square = 0.701, df = 1, p = 0.592). The association between time and dominant knowledge accessing mode, however, was significant at the 0.05 level of significance (chi-square = 9.478, df = 2, p = 0.009).

As observed from Table 6, the noetic problem solvers seemed to reflect a different time pattern. Hence, a post hoc analysis

Table 6

Frequency of Protocols Collected*
from Each Category of Problem Solver
and the Interval of Time Required
to Solve a Set of Three Problems

Identified Time Intervals	Dominant Knowledge Accessing Mode: Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
5.0 - 10.0 minutes	8	6	6	3	8	4	35
10.1 - 15.0 minutes	8	13	5	8	2	8	44
15.1 - 20.0 minutes	6	3	7	4	8	5	33
20.1 - 25.0 minutes	1	1	4	5	1	5	17
25.1 - 30.0 minutes	1	-	-	3	5	-	9
30.1 + minutes	-	1	2	1	-	2	6
Total	24	24	24	24	24	24	144

*24 (8 problem solvers per category, each problem solver solving 3 problems).

Note: With the time intervals dichotomized into 15 minutes or less and larger than 15 minutes:

1) chi-square (time, category) = 10.57, df = 5, p = 0.061;

2) chi-square (time, gender) = 0.701, df = 1**, p = 0.592;

3) chi-square (time, dominant K.A.M.) = 9.478, df = 2, p = 0.009.

4) chi-square (time, dominant K.A.M.) = 9.478, df = 1, p = .003 where empirical and rational problem solvers are grouped together.

**When df = 1, Yates' Correction for Continuity is used.

was performed on the two time intervals (fifteen minutes or less and larger than fifteen minutes) and the noetic problem solvers as one category and the empirical and rational problem solvers combined as another category. At the 0.05 level of significance, there was an association between time intervals and the two categories of problem solvers (chi-square = 9.478, df = 1, p = 0.003). These results indicated that the noetic problem solvers, were distinct. In other words, a different pattern, in regards to time, was obtained by noetic problem solvers than empirical or rational problem solvers. Specifically, it was observed that thirty-five noetic protocols out of forty-eight (73%) were solved in fifteen minutes or less, whereas only twenty-two empirical and rational protocols (46%) were solved in this time.

Appendices E and G display the total time required by each problem solver to solve each problem. Table 7 displays the frequency of problem solvers in relation to their pattern of times required to solve the three problems. It may have been speculated that due to the familiarity with the problem structures, problem solvers would show a decreasing pattern in the total time required to solve the first problem to the third problem. Despite this speculation, it was observed that only twelve problem solvers out of forty-eight (25%) displayed this

Table 7

Frequency of Problem Solvers*
in Relation to the Pattern of Times
Required to Solve the Problems

Pattern of Times	Dominant Knowledge Accessing Mode: Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
Increased Time Required for Problem Sequence 1, 2, 3**	-	1	2	1	1	2	7
Decreased Time Required for Problem Sequence 1, 2, 3	4	1	3	1	2	1	12
Varied Time Required for Problem Sequence 1, 2, 3	4	6	3	6	5	5	29
Total	8	8	8	8	8	8	48
Task Problem Required Longest Time	2	2	3	-	1	1	9
Interview Problem Required Longest Time	5	5	3	7	6	5	31
Award Problem Required Longest Time	1	1	2	1	1	2	8
Total	8	8	8	8	8	8	48

*8 problem solvers per category.

**Problem Sequence 1, 2, 3 refers to the first problem solved, second problem solved, third problem solved.

pattern. It was also observed that seven problem solvers (15%) displayed an increasing pattern; while twenty-nine problem solvers (60%) did not display an increasing or decreasing pattern. Thirty-one problem solvers out of forty-eight (65%) took the longest time to solve the 'Interview Problem' (refer to the second part of Table 7).

To further determine the effects of time on the dominant knowledge accessing mode, gender, and specific problem, a multivariate analysis of variance was performed (see Table 8). In this analysis, total time represented the dependent variable, while the dominant knowledge accessing mode, gender, and problem represented the independent variables.

As seen from this table, there was an effect attributable to the gender factor, at the 0.05 level of significance ($p = 0.022$). This indicated that the solution times for the problems were globally distinct for males and females. To locate the problems where this gender effect was observed, a univariate analysis for each problem was performed as post hoc analysis (see Table 9). At the 0.05 level of significance, no significant gender effect was found for the 'Task Problem' or the 'Interview Problem'. However, a significant gender effect was observed for the 'Award Problem'. This indicated that in regards to time, males and females solved this problem differently.

Table 8

Descriptive Statistics and
Multivariate Analysis of Variance
for Time Required to Solve a Problem

Variables K.A.M.	N	Sex	Problems	Mean	STDV
Noetic	8	M	Task	12.20	5.67
			Interview	16.70	5.65
			Award	10.39	2.81
	8	F	Task	11.89	3.09
			Interview	14.76	4.69
			Award	13.45	7.27
Empirical	8	M	Task	15.94	6.33
			Interview	20.49	12.61
			Award	13.71	4.44
	8	F	Task	12.96	4.07
			Interview	21.44	7.51
			Award	17.03	7.43
Rational	8	M	Task	14.26	6.68
			Interview	21.33	5.49
			Award	11.74	4.50
	8	F	Task	11.44	2.60
			Interview	22.29	6.53
			Award	16.66	5.48

Summary of Multivariate Analysis of Variance

Source of Effect	Statistic	Value	df	F	p-prob
Gender	Wilks' Criterion	0.789	(3,40)	3.57	0.022
	Hotelling-Lawley	0.268	(3,40)	3.57	0.022
K.A.M.*	Wilks' Criterion	0.837	(6,80)	1.24	0.296
	Hotelling-Lawley	0.188	(6,78)	1.22	0.230
K.A.M x Gender	Wilks' Criterion	0.959	(6,80)	0.28	0.943
	Hotelling-Lawley	0.043	(6,78)	0.28	0.945

*K.A.M - dominant knowledge accessing mode

Table 9

Univariate Analysis of Variance
as Post Hoc Analysis
for each Dependent Variables

Source	SS	df	MS	F	p-prob
Task Problem					
Gender	49.817	1	49.817	2.00	0.165
K.A.M.*	48.000	2	24.000	0.96	0.391
K.A.M. x Gender	17.899	2	8.949	0.36	0.701
Residual	1048.404	42			
Interview Problem					
Gender	0.001	1	0.001	0.00	0.997
K.A.M.	346.579	2	173.289	2.99	0.061
K.A.M. x Gender	22.330	2	11.165	0.19	0.826
Residual	2433.630	42	57.944		
Award Problem					
Gender	170.253	1	170.253	5.49	0.024
K.A.M.	98.520	2	49.260	1.59	0.216
K.A.M. x Gender	8.175	2	4.088	0.13	0.877
Residual	1301.590	42	30.990		

*K.A.M. - dominant knowledge accessing mode

Contribution/Integration of Criteria to the Problem Definition

The use or non-use of added criterion statements and highlighted statements was important when determining the criteria a problem solver introduced or contributed to the problem definition and to determine how an individual integrated the above criteria in his/her problem solution. Table 10 indicates the frequency of problem solvers who solved each problem by 1) contributing personal criteria to the definition of the problem; 2) highlighting criteria found in the body of the problem; 3) adding personal criteria and highlighting criteria; or 4) none of the above.

As observed from this table, in one hundred and one protocols from one hundred forty-four collected (70%), problem solvers added criteria from their own resources, highlighted criteria from the main scenario, or both added and highlighted criteria. Specifically, in twenty-nine protocols (20%) problem solvers added criteria only; in forty-three (30%) problem solvers highlighted criteria only; and in twenty-nine (20%), problem solvers both added and highlighted criteria; while in forty-three (30%) problem solvers did none of the above.

With added criteria only, highlighted only, and added/highlighted criteria regrouped in one category, chi-square tests were performed to determine if an association existed between the criteria introduced and the dominant knowledge accessing mode and the criteria introduced and gender.

Table 10

Frequency of Problem Solvers*
Introducing or Contributing Criteria
to the Definition of the Problems

Problem	Added or Highlighted Criterion	Dominant Knowledge Accessing Mode: Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
Task	Added Only	4	2	5	1	2	2	16
	Highlighted Only	-	-	1	2	2	2	7
	Added/Highlighted	-	-	-	-	1	-	1
	None of the Above	4	6	2	5	3	4	24
Interview	Added Only	2	-	1	1	-	1	5
	Highlighted Only	2	2	3	3	3	2	15
	Added/Highlighted	1	4	2	3	2	3	15
	None of the Above	3	2	2	1	3	2	13
Award	Added Only	2	2	1	1	-	2	8
	Highlighted Only	1	3	3	5	5	4	21
	Added/Highlighted	3	3	3	2	-	2	13
	None of the Above	2	-	1	-	3	-	6
Total		24	24	24	24	24	24	144

*8 problem solvers per category.

Note: With added only, highlighted only, and highlighted/added regrouped in one category:

1) chi-square (criteria introduced, dominant K.A.M.) = 0.598, df = 4, p = 0.961;

2) chi-square (criteria introduced and gender) = 2.527, df = 2, p = 0.282.

No association was found at the 0.05 level of significance (chi-square = 0.598, df = 4 p = 0.961; chi-square = 2.527, df = 2, p = 0.282, respectively).

It was observed that the type of personal criteria added to the problem definition by the categories of problem solvers was similar. Examples of the kind of personal criteria added to the 'Task Problem' are:

> Right now I am looking for something that is fun and creative (ID: 37, noetic male).
>
> Time is important to me and this is time consuming (ID: 12, empirical male).
>
> Let me see, I want to minimize my work and maximize my mark. I also want to get some variety in what I do (ID: 8, rational male).
>
> I am looking for something that is easy (ID: 39, noetic female).
>
> I would like some variation in the three (ID: 20, empirical female).
>
> I don't want to choose anything that is boring. This sounds boring (ID: 17, rational female).

Examples of the kind of personal criteria added to the 'Interview Problem' are:

> Ok, the successful candidate would have to teach a number of courses within the social science curriculum. As a consequence, should be flexible (ID: 42, noetic male).
>
> I'm looking for a style with flare or flamboyance (ID: 2, empirical male).
> You know there are several things you look for, consistency is a big thing (ID: 47, rational male).
>
> I think distinct is being something a little different (ID: 32, noetic female).

> There is an advantage going for young people. We are getting older and we don't get young blood (ID: 15, empirical female).
>
> I think the students have to be able to talk to the teacher. I consider that to be important (ID: 3, rational female).

Examples of the kind of personal criteria added to the 'Award Problem' are:

> I believe that the length of time a teacher has taught at the school maybe a factor in choosing the candidate. This is especially true if the teacher is going to retire or resign (ID: 42, noetic male).
>
> I'm inclined to use the old 'Oscar's' logic. He's a young actor, he'll be around for more triumphs. We'll award him at a later date (ID: 1, empirical male).
>
> This person has left a legacy, that appeals to me (ID: 45, rational male).
>
> Contributions over the years is what is important (ID: 39, noetic female).
>
> I'm always influenced by someone who is community minded (ID: 18, empirical female).
>
> Length of time teaching can not be ignored (ID: 34. rational female).

It was observed that the type of criteria highlighted from the main scenario of each problem (see Table 2) was the same for all categories of problem solvers. Some highlights, however, were more prevalent than others. In the 'Task Problem', the number of pages in the text book was critical. In the 'Interview Problem' identifying a distinct teaching style was important, whereas in the 'Award Problem', the contribution made to teaching and the school environment prevailed.

Table 11 displays the frequency of protocols collected from each category of problem solver in relation to the pattern of when criteria were introduced in the problem definition (whether it be added criteria, highlighted criteria, or a combination of both). As a reminder, 'Step 1' represented the reading of the main scenario, while 'Step 2' involved the reading of the mini scenarios. Subsequent steps comprised units of mental activity such as a solution to the problem, a review of preferred mini scenarios, or a rereading of the main scenario. As seen from this table, criteria were introduced during the first four steps of the problem solving process. It was observed that in seventy-three protocols out of one hundred and one (72%), criteria were introduced during 'Step 2' and 'Step 3'; in twenty-five protocols (25%), criteria were introduced in 'Step 1'.

Strategies Used to Solve the Problems

As previously reported, a strategy for solution was identified for each protocol (see Table 3). In Strategy A, the problem solver reviewed all elements of the problem before attempting a solution to the problem. In Strategy B, the problem solver proceeded as in Strategy A, but, addressed the elements of the problem as the elements were reviewed. In Strategy C, the problem solver attempted a solution to the problem before all elements were addressed by making definite decisions to include elements (C.1), exclude elements (C.2), or to both include and

Table 11

Frequency of Problem Solvers*
in Relation to the Pattern of Introducing Criteria
to the Problem Definition

Problem	K.A.M.	Sex	Steps 1	2	3	4	Total # Contributing
Task	N	M	-	-	4	-	4
		F	2	-	-	-	2
	E	M	1	1	3	1	6
		F	1	1	1	-	3
	R	M	-	-	5	-	5
		F	-	1	3	-	4
Interview	N	M	1	1	3	-	5
		F	4	1	1	-	6
	E	M	1	2	2	1	6
		F	3	1	3	-	7
	R	M	-	3	2	-	5
		F	3	1	2	-	6
Award	N	M	1	1	4	-	6
		F	3	1	4	-	8
	E	M	1	5	1	-	7
		F	2	4	1	1	8
	R	M	1	3	1	-	5
		F	1	5	2	-	8
Total			25	31	42	3	101

*8 problem solvers per category.

exclude elements. Table 12 displays the frequency of problem solvers and strategy used by each category of problem solver to solve each problem.

From this table, it was observed that thirty-nine protocols from one hundred forty-four collected (27%) used Strategy A to solve the problems. Sixty (42%) used Strategy B, with forty-five (31%) using Strategy C. In addition, it was observed that noetic problem solvers (37 out of 48, 77%) and rational problem solvers (36 out of 48, 75%) relied on Strategies A and B to solve thei problems; while empirical problem solvers (43 out of 48, 90%) relied on Strategies B and C.2 to solve their problems.

With Strategies C.1, C.2, C.3 regrouped in one category, albeit Strategy C.2 being the most popular 'C' strategy, a chi-square test was performed to determine if there was an association between Strategies A, B, and C and gender (see Table 13). At the 0.05 level of significance, no association was found (chi-square = 3.232, df = 2, p = 0.197).

In a final analysis, to determine if an association existed between Strategies A, B, and C and the dominant knowledge accessing mode, a chi square test was performed. At the 0.05 level of significance, an association was found (chi-square = 15.03, df = 4, p = 0.005. To locate the type of association between these two variables, post hoc analysis was applied on strategies. Deleting Strategy A, no association was found between strategies and dominant knowledge accessing mode at the 0.05 level of significance (chi-square = 1.157, df = 2,

Table 12

Frequency of Problem Solvers*
and Strategies Used by Each Category
of Problem Solver to Solve Each Problem

Strategy	Problems**	Dominant Knowledge Accessing Mode: Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
Strategy A: All Elements Reviewed	T	5	2	1	1	4	3	16
	I	3	4	1	-	3	2	13
	A	4	1	1	-	2	2	10
Strategy B: Elements Addressed	T	-	4	5	1	2	2	14
	I	3	2	4	1	3	5	18
	A	2	7	6	5	4	4	28
Strategy C.1: Decisions to Include	T	-	-	-	-	-	-	-
	I	-	-	-	-	-	-	-
	A	-	-	-	-	1	-	1
Strategy C.2: Decisions to Exclude	T	1	2	2	6	-	2	13
	I	1	2	3	7	1	1	15
	A	1	-	-	3	1	2	7
Strategy C.3: Decisions to Include and to Exclude	T	2	-	-	-	2	1	5
	I	1	-	-	-	1	-	2
	A	1	-	1	-	-	-	2
Total		24	24	24	24	24	24	144

*8 problem solvers per category.

**T - 'Task Problem'
I - 'Interview Problem'
A - 'Award Problem'

Table 13

Frequency of Problem Solvers*
and the Association between Strategies Used
and Dominant Knowledge Accessing Mode

Strategy	Dominant Knowledge Accessing Mode Noetic	Empirical	Rational	Total
Strategy A	19	4	16	39
Strategy B	18	22	20	60
Strategy C**	11	22	12	45
Total	48	48	48	145

*48 Problem Solvers per dominant K.A.M.

Note: **With strategies C.1, C.2, C.3 regrouped in one category:

1) chi-square (strategies, gender) = 3.232, df = 2, p = 0.197);

2) chi-square (strategies, dominant K.A.M.) = 15.03, df = 4, p = 0.005.

Post Hoc Analysis on Strategy:

3) chi-square (strategies B and C, dominant K.A.M.) = 1.57, df = 2, p = 0.542;

4) chi-square (strategies A and B, dominant K.A.M.) = 8.88, df = 2, p = 0.012;

5) chi-square (strategies A and C, dominant K.A.M.) = 14.81, df = 2, p = 0.001.

Post Hoc Analysis on dominant K.A.M.:

6) chi-square (strategies, empirical and noetic dominant K.A.M.) = 13.849, df = 2, p = 0.001;

7) chi-square (strategies, empirical and rational dominant K.A.M.) = 10.236, df = 2, p = 0.006;

8) chi-square (strategies, rational and noetic dominant K.A.M.) = 0.406, df = 2, p = 0.818.

p = 0.542. However, when using Strategy A and B or when using Strategy A and C, an association was found between strategy and dominant knowledge accessing mode at the 0.05 level of significance (chi-square = 8.88, df = 2, p = 0.012; chi-square = 14.81, df = 2, p = 0.001 respectively). These result indicated that Strategy A was distinct. In other words, a different pattern was obtained by using Strategy A than Strategies B or C.

In addition, a post hoc analysis was applied on dominant knowledge accessing modes. With the empirical problem solvers deleted, no association was found between strategies and dominant knowledge accessing modes at the 0.05 level of significance (chi-square = 0.406, df = 2, p = 0.818). However, with empirical and noetic problem solvers and empirical and rational problem solvers, an association was found between strategies and dominant knowledge accessing mode at the 0.05 level of significance (chi-square = 13.849, df = 2, p = 0.001; chi-square = 10.236, df = 2, p = 0.818; respectively). These results indicated that empirical problem solvers were distinct. In other words, a different pattern, in regards to strategy, was obtained by empirical problem solvers than noetic or rational problem solvers.

Table 14 displays the frequency of problem solvers in relation to their pattern of strategies required to solve the three problems regardless of the order of presentation. For example, the 'A - A - A' pattern indicates that the problem solver solved each of his/her problems utilizing Strategy A. Whereas the 'A - B - C.2' pattern indicates that the problem

Table 14

Frequency of Problem Solvers*
in Relation to the Pattern of Strategies
Used to Solve the Problems

Pattern of Strategies	Dominant Knowledge Accessing Mode: Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
3 Strategies the Same for Problem Sequence 1, 2, 3**							
A - A - A	2	1	1	-	2	2	8
B - B - B	-	1	4	-	2	2	9
C.2 - C.2 - C.2	-	-	-	2	-	-	2
C.3 - C.3 - C.3	1	-	-	-	-	-	1
First 2 Strategies the Same for Problem Sequence 1, 2, 3							
A - A - B	-	1	-	-	-	-	1
C.2 - C.2 - B	-	1	1	3	-	-	5
C.2 - C.2 - C.3	-	-	1	-	-	-	1
C.3 - C.3 - C.1	-	-	-	-	1	-	1
Last 2 Strategies the Same for Problem Sequence 1, 2, 3							
A - B - B	-	1	-	-	-	-	1
B - C.2 - C.2	-	-	-	1	-	1	2
C.2 - B - B	-	1	-	-	-	-	1
First/Last Strategies the Same for Problem Sequence 1, 2, 3							
A - B - A	2	-	-	-	-	-	2
B - A - B	-	1	-	-	1	-	2
B - C.2 - B	-	1	1	1	-	1	4
3 strategies different for Problem Sequence 1, 2, 3							
A - B - C.2	1	-	-	-	-	1	2
A - C.2 - B	1	-	-	1	1	-	3
A - C.3 - C.2	-	-	-	-	1	-	1
C.2 - C.3 - B	1	-	-	-	-	1	2
Total	8	8	8	8	8	8	48

* 8 problem solvers per group.

**Problem Sequence 1, 2, 3 refers to the first problem solved, second problem solved, third problem solved.

solver used Strategy A to solve his/her first problem, Strategy B for the second problem, and Strategy C.2 for the third problem.

From this table, it was observed that twenty out of the forty-eight problem solvers (42%) used the same strategy to solve all three problems. Out of these twenty problem solvers, the empirical male problem solvers were the most consistent in using the same strategy for solution (5 problem solvers out of 8, 63%). Another twenty problem solvers (42%) solved two problems using the same strategy. Only eight problems solvers (17%) used different strategies to solve each problem. Of these eight problem solvers, three solved two of their problems utilizing two different 'C' strategies.

Solutions to the Problems - Selected Responses

As previously explained, solving a problem entailed the selection of three mini scenarios from nine mini scenarios. These nine mini scenarios were constructed such that three mini scenarios reflected the noetic knowledge accessing mode, three reflected the empirical, while three reflected the rational. Appendix I displays the actual selections of mini scenarios made by each problem solver solving each problem; while Appendix J displays the number of noetic, empirical, and rational responses made by each problem solver for each problem.

Table 15 displays the frequency of problem solvers selecting the same mini scenario. It was observed from this table that the

Table 15

Frequency of Problem Solvers*
Selecting the Same Mini Scenario

Problem	Mini Scenarios Identified Modality		Dominant Knowledge Accessing Mode: Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
Task	1	Empirical	4	2	3	4	6	1	20
	2	Noetic	5	5	4	2	2	3	21
	3	Rational	2	-	-	3	3	4	12
	4	Empirical	2	1	5	2	3	-	13
	5	Noetic	3	4	-	-	-	1	8
	6	Empirical	1	2	3	4	4	2	16
	7	Rational	3	3	3	1	2	4	17
	8	Rational	1	2	4	1	1	2	11
	9	Noetic	3	5	2	7	3	7	26
Interview	1	Rational	1	2	2	-	3	1	9
	2	Noetic	4	2	2	1	1	2	12
	3	Empirical	1	-	-	-	1	-	2
	4	Noetic	2	4	3	5	5	5	24
	5	Empirical	1	3	5	5	5	4	23
	6	Rational	4	1	4	3	2	6	20
	7	Noetic	6	4	3	3	-	2	18
	8	Empirical	4	4	3	6	4	3	24
	9	Rational	1	4	2	1	3	1	12
Award	1	Noetic	1	-	3	-	2	3	9
	2	Rational	5	2	1	3	1	2	14
	3	Rational	-	-	1	1	2	-	4
	4	Empirical	6	2	3	3	4	3	21
	5	Rational	2	1	1	3	1	3	11
	6	Empirical	3	7	6	5	5	5	31
	7	Noetic	-	5	3	3	4	5	20
	8	Empirical	1	4	4	3	2	1	15
	9	Noetic	6	3	2	3	3	2	19
Total			72	72	72	72	72	72	432

*8 problem solvers per category, each problem solver solving three problems.

most popular mini scenarios for the 'Task Problem' were numbers 1, 2 and 9. Twenty (42%), twenty-one (44%), twenty-six (54%) out of forty-eight problem solvers selected these mini scenarios respectively. In the 'Interview Problem', the most popular mini scenarios were numbers 4, 5, and 6. Twenty-four (50%), twenty-three (48%), and twenty (42%) out of forty-eight problem solvers selected these mini scenarios, respectively. In the 'Award Problem', the most popular mini scenarios were numbers 4, 6, and 7. Twenty-one (44%), thirty-one (65%), and twenty (42%) selected these mini scenarios respectively. It should be noted, however, that the popular and unpopular mini scenarios were the same for all categories of problem solvers.

Table 16 is a contingency table displaying the frequency of selection of mini scenarios in agreement with the dominant knowledge accessing mode. To determine if an association existed between the selection of mini scenarios and the dominant knowledge accessing mode, a chi-square test was performed. At the 0.05 level of significance, no association was found.

Table 17 displays the frequency of protocols and pattern of selection of mini scenarios in agreement with dominant knowledge accessing mode. With two and three in agreement regrouped in one category, chi-square tests were performed on agreement and gender and agreement and dominant knowledge accessing mode. The purpose of these tests were to determine if an association existed. At the 0.05 level of significance no association was found between agreement and gender (chi-square = 1.413, df = 2, p = 0.502).

Table 16

Contingency Table for
Frequency of Selection of Mini Scenarios
in Agreement with Dominant Knowledge Accessing Mode

Identified Modality for Mini Scenarios	Dominant Knowledge Accessing Mode Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
Noetic	30	32	22	24	20	31	159
Empirical	23	25	30	32	34	18	162
Rational	19	15	20	16	18	23	111
Total	72	72	72	72	72	72	432

Note: 1) chi-square (identified modality, dominant K.A.M.) = 14.020, df = 10, p = 0.175.However, an association was

Table 17

Frequency of Protocols* in Relation to the Pattern of Selection of Mini Scenarios in Agreement with Dominant Knowledge Accessing Mode

Number of Selections in Agreement dominant K.A.M.	Dominant Knowledge Accessing Mode: Noetic M	Noetic F	Empirical M	Empirical F	Rational M	Rational F	Total
3 in Agreement	3	3	-	-	-	-	6
2 in Agreement	2	5	10	9	3	5	34
1 in Agreement	17	13	10	14	12	13	79
0 in Agreement	2	3	4	1	9	6	25
Total	24	24	24	24	24	24	144
Selected 1 of Each	13	5	7	10	4	6	45

*24 (8 problem solvers per category, each problem solver solving 3 problems)

Note: With the two and three in agreement regrouped:

1) chi-square (agreement, gender) = 1.413 , df = 2, p = 0.502;

2) chi-square (agreement, dominant K.A.M.) = 13.335, df = 4, p = 0.010.

Post Hoc Analysis on Agreement:

3) chi-square (3 + 2 and 1 in agreement, dominant K.A.M.) = 3.673, df = 2 , p = 0.158;

4) chi-square (3 + 2 and 0 in agreement, dominant K.A.M.) = 10.976, df = 2, p = 0.005;

5) chi-square (1 and 0 in agreement, dominant K.A.M.) = 6.527, df = 2, p = 0.037.

Post Hoc Analysis on K.A.M.:

6) chi-square (agreement, noetic and empirical K.A.M.) = 1.792, df = 2, p = 0.589;

7) chi-square (agreement, empirical and rational K.A.M.) = 9.502, df = 2, p = 0.009;

8) chi-square (agreement, noetic and rational K.A.M.) = 6.645, df = 2, p = 0.035.

However, an association was found between agreement and dominant knowledge accessing mode at the 0.05 level of significance (chi-square = 13.335, df = 4, p = 0.010).

To locate the type of association between agreement and dominant knowledge accessing mode, a post hoc analysis was applied on agreement. With 0 in agreement deleted, no association was found between agreement and dominant knowledge accessing mode at the 0.05 level of significance (chi-square = 3.673, df = 2, p = 0.158). With one in agreement deleted, an association was found at the 0.05 level of significance (chi-square = 10.976, df = 2, p = 0.005). With 3 + 2 in agreement deleted, no association was found at the 0.05 level of significance (chi-square = 6.527, df = 2, p = 0.037). The results indicated that the association was localized in the extremes.

In addition, a post hoc analysis was applied on dominant knowledge accessing mode. With rational problem solvers deleted, no association was found between agreement and dominant knowledge accessing mode at the 0.05 level of significance (chi-square = 1.792, df = 2, p = 0.589). With noetic problem solvers deleted an association was found at the 0.05 level of significance (chi-square = 9.502, df = 2, p = 0.009). With empirical problem solvers deleted no association was found at the 0.05 level of significance (chi-square = 6.645, df = 2, p = 0.035). The rational problem solvers were distinct. In other words, a different agreement pattern was obtained by the rational problem

solvers than the noetic or empirical problem solvers.

Specifically, 119 out of 144 protocols collected (83%) selected at least one mini scenario in agreement with the dominant knowledge accessing mode; while the noetic problem solvers were the only problem solvers selecting all three mini scenarios in agreement.

Content of the Protocols

Although it is not the main focus of this study to analyze the types of comments articulated by the problem solvers while solving the problems, interesting subjective observations were made during experimentation. Noetic problem solvers took few notes and were impulsive in their decision making processes. Their explanations for including or excluding a mini scenario were primarily personalized.

For example, in the final step towards solving the 'Interview Problem', a noetic male problem solver (ID: 48) said:

> When I read this, we have nine teachers with nine distinct, different teaching methods. I guess I have to decide which of the three kinds of methods I am comfortable with. That, I am gathering is my task. I know my three right off the bat. I could almost rank these in terms of what I like in teaching styles. I am an eclectic person. The way these are presented, there is a preponderance of style. I liked 7, 8, 9.

Another noetic male problem solver (ID: 37) read the description for candidate 3 of the 'Interview Problem' and reacted to the description by saying:

> My initial and emotional reaction is that she is probably prim and a pain in you know where. She would be boring to be around in a staff room. I don't know what it means that she has little tolerance for the unconventional. However, my reading into that, is; probably she is bluntly straight forward and loses track easily. So, I find it hard to believe that she will move from particular to global situations. So, my emotional response to this candidate is that I would immediately dismiss her. I don't believe the facts are consistent as they are described to me. So, I don't trust her.

A noetic female problem solver (ID: 40) read the description for candidate 4 of the 'Award Problem' and reacted to the description by saying:

> She won an award for community work. Oh, I like that. She is a good possibility. This award was suppose to be for recognizing three teachers unselfish contributions to teaching and the school environment. Oh, it doesn't say they should be out there in the community. However, that makes them a better teacher. It is better that they don't just stay within the walls of the school. She is dynamite, I just like her.

A noetic male problem solver solving the 'Task Problem' (ID: 13) read each task description and reacted instantaneously to each description:

> Number 1 is a possibility. Number 2 is a no. Number 3 is a no, because it is a contradiction of number 1. Number 1 goes from a specific to a general. Number 3 is the opposite. I'd rather go from a specific to general than from general to specific. Number 4 is a no. Number 5 is a no. Number 6 is a possibility. Number 7 is a yes. Number 8 is a no. Number 9 is a yes. I would choose 1, 7, and 9 because they are more in keeping with the way I go about doing things.

Empirical problem solvers gave lengthy and thorough explanations for whatever they did. For example, an empirical male problem solver (ID: 11) read the 'Interview Problem' from start to finish without stopping. During a second review of the

nine mini scenarios, he commented on each mini scenario. Part way through this review, he stopped and said:

> Yes, there are nine candidates here. I think I am going to have to go back to the beginning. I think it is important to put down major pros and cons. I'm getting too many details to keep track of.

An empirical female problem solver (ID: 30) took five steps to solve the 'Award Problem'. In steps 2 to 4, she considered the nine mini scenarios, commented on each mini scenario, and excluded four mini scenarios. Much deliberation still took place in Step 5:

> So we have five left. I don't know what to do about this poor guy dying (rereads mini scenario 9). Oh, he sound like somebody really worth giving an award to. Yes, I think we will give it to him. So basically, I think I will have to eliminate my Chinese woman. She sounds so wonderful. Then, I have to decide on the retiring library setter upper. Maybe, I should go with the field trips. My instinct is too take the Chinese lady and eliminate the other two. I don't feel particularly compassionate to the British lady who set up the library. I don't know. So, maybe I'll get rid of her just for that reason.

Many empirical problem solvers made copious notes and compared and contrasted mini scenarios. An excerpt taken from an empirical male protocol (ID: 19) solving the 'Interview Problem' illustrates this comparing and contrasting technique.

> So, the follow through is candidates 2, 4, 5, 7; they all seem to be the same type. Candidates 1, 3, and 6 seem to be similar. (Reads the description for candidate 8) The last two I guess are unconventional, candidates 8 and 7. They are unconventional in terms of what some people might expect from a factual sort of person. It is candidates 1, 3, and 6. So from 6 we go to candidate 8. If I have the right set up. (Reads the description for candidate 9) He is still going to be organized. So, we are still looking at logic versus fact. So, we are still looking at 1, 3, 6, and 8.

> This candidate 9 is still another one that goes from general to specific; candidate 8 as well. Candidates 8 and 9, the difference between these two is that this is logic (9) and this is fact (8). So we still have a person who has principles, candidate 1. Maybe I made a mistake on candidate 8. So candidate 5 goes to candidate 8 and candidate 6 goes to candidate 9. So we've got, I believe, two groups: group A, candidates 1, 3, 6, and 8; group B, candidates 2, 4, 5, 7, 9.

Rational problem solvers, on the other hand, gave logical explanations for what they did. After careful consideration of each mini scenario in the 'Task Problem', a rational male problem solver (ID: 26) made his final selection.

> So my final choices would be task 1, 3, and 9 for the following reasons. Task number 1 provides me with the option of going through the book and making a good summary of each chapter. Task number 3 would then be a visual summary of the same thing. Task number 9 would force me to focus on the practical implications.

Another rational male problem solver (ID: 8), when solving the 'Interview Problem' logically organized the nine candidates to be considered for an interview into three groups. He then was concerned about fairness.

> In presenting three candidates, I don't want to give my choices. I want to present choices that would be made by the committee. So, I would want to be somewhat fair in choosing three. Ok, to make sure that I am choosing three teachers that are fairly different, so that the committee can decide, I want to present the best one. I have three different groups. So now I have to choose the best candidate from each group.

As previously indicated, many rational problem solvers devised systems to rank order or to categorize each mini scenario. By using these devised systems, many of the mini scenarios were compared and contrasted.

For all categories of knowledge accessing modes, many problem solvers found the first two choices easy. The third choice required more deliberation.

> So, that leaves me with 7, 2, 4, and 5. I'm going to keep number 7 automatically because... I'm going to short list number 2 because... In choosing between 4 and 5... (ID: 37, noetic male)

> So, now I have to decide between giving up my outdoor education person or my Indian person (ID: 19, noetic female).

> I'm very much leaning towards number 8 and 4. Alright, 4 and 8 are very good. The only hesitation on 6 was the lack of time or too much work and leaving myself without enough time to do it. On the other hand, just because there is a little end product in number 6 doesn't mean that five ideas would write up very easily and that could be the case. In other words, if the text book had 25, 30, or 40 ideas and so many chapters, it would be hard to write three pages just on each one of them. So even number 6 is not that bad. I'm really leaning towards the even numbers 4, 6, and 8 (ID: 2, empirical male)

> Six is definitely a candidate. Seven is a candidate. I still have 2 and 4 (ID: 33, empirical female).

> Now for the third one, I'm torn between 5 and 6 (ID: 28, rational female).

> So I'm taking number 9 and number 2. Now I have a choice between 6 and 8 (ID: 45, rational male).

Summary of Results

In summary, descriptive statistics, chi-square tests, and a multivariate and univariate analysis of variance were performed on the data. The adopted level of significance was 0.05.

No association existed between the number of steps required

to solve the problems and category of problem solver, nor between the number of steps required to solve the problems and gender. In relation to the pattern of steps, the majority of problem solvers used the same number of steps to solve each of their three problems or displayed a decreasing pattern in the number of steps required.

No association existed between time and category of problem solver, nor between time and gender. An association between time and dominant knowledge accessing, however, was found. A different pattern, in regards to time was obtained by noetic problem solvers. In relation to the pattern of time, the majority of problem solvers did not display an increasing time pattern or a decreasing time pattern from their first problem solved to their last. The solution times for the problems were globally distinct for males and females. Specifically, in regards to the 'Award Problem' males and females solved this problem differently.

No association existed between the introduction of criteria and the dominant knowledge accessing mode, nor between the introduction and gender. However, most criteria was introduced after the elements of the problem had been reviewed.

No association was found between strategies and gender. However, an association was found between strategies selected to solve the problems and the dominant knowledge accessing mode. A different pattern was obtained by empirical problem solvers.

No association was found between the selection of mini scenarios in agreement with dominant knowledge accessing mode and gender. However, an association was found between the pattern of agreement and dominant knowledge accessing mode. A different pattern was obtained by rational problem solvers.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

The following chapter presents the conclusions of this study and offers recommendations for future research. While this present research has been exploratory, it has demonstrated that the solving of complex, selection-type, ill-defined problems is amendable to study. The research provides a sketch of the processes involved in solving these types of problems and provides information concerning protocol analysis as a method of research.

Conclusions of the Research

This research was designed to explore the processes and patterns that developed as individuals solved selection type, ill-defined problems. Specifically, the objectives of the research were 1) to determine what criteria an individual introduced or contributed to the definition of the problem; 2) to determine how an individual integrated the above criteria to arrive at a solution; 3) to determine the strategies that were used to solve the problem; and 4) to determine if there was a relationship between an individual's problem solving behaviour and his/her dominant knowledge accessing mode. These problem solving behaviours refer to the selection and introduction of

criteria, solution patterns, choice and application of a strategy, and final selection.

Contribution to the Problem Definition

The first objective of this study was to determine what an individual introduced or contributed to the definition of the problem. All categories of problem solvers introduced or contributed criteria to the definition of the problem. This was achieved by adding criteria personal resources, by highlighting criteria contained in the problem environment, or by a combination of both. No association was found between the introduction or contribution of criteria and the dominant knowledge accessing mode (see Table 10).

It was observed, however, that the empirical and rational problem solvers tended to highlight criteria contained in the main scenario more so than the noetic problem solvers. This observation is in keeping with the global definitions of noetic, empirical, and rational knowledge accessing modes. The noetic problem solvers view of reality is determined by a commitment to personal or subjective experience as the main source of data collection. Whereas the empirical knowledge accessing mode views reality by a commitment to sensory perceptions as the main source of data collection; and the rational knowledge accessing mode views reality by a commitment to concepts or information currently available as the main source of data collection.

Differences in the actual information added to the problem definition (for example many problem solvers added the criterium, age when deciding who should be interviewed in the 'Interview Problem') or the highlights from the main scenario were not discriminated among the problem solving categories. Suffice to say, whatever was added or highlighted redefined the problem for the problem solver.

Integration of Contribution

The second objective of this study was to determine how an individual integrated his/her contribution to the problem to arrive at a solution. It was observed that the introduction or contribution of criteria, in most cases, were integrated in the problem definition after the elements of the problem had been reviewed (see Table 11). In other words most criteria were introduced during Step 3 (the second review of preferred mini scenarios).

Strategies Used to Solve the Problems

The third objective of this study was to determine the strategies that were used to solve the problems. Five strategies for solving the problems in this study were identified. In Strategy A, the problem solver reviewed all elements of the problem before attempting a solution. In Strategy B, the problem

solver addressed elements of the problem as the elements were being reviewed whereas in Strategy C, the problem solver attempted a solution to the problem before all elements of the problem were reviewed. This attempted solution was completed by making decisions to include elements only (C.1); making decisions to exclude elements only (C.2); or making decisions to both include and exclude elements (C.3).

The predominant strategy used by problem solvers to solve the problems in this study involved addressing elements of the problem as the elements were reviewed (Strategy B) (see Table 13). The second strategy most often used involved a review of all elements of the problem before attempting a solution to the problem (Strategy A); and the third, the exclusion of elements as elements were reviewed (Strategy C.2). The least popular strategies involved 1) making decisions only to include elements, and 2) making decisions to include or exclude elements (C.1, C.3 respectively).

It was observed that the noetic and rational problem solvers used Strategies A and B, predominantly, to solve the problems, while the empirical problem solvers relied mainly on Strategies B and C.2. No association was found between the strategies used to solve the problems and gender of the problem solver. However, an association was found between strategies and the dominant knowledge accessing mode. A different pattern, in regards to strategy was obtained by empirical problem solvers.

The relationship between the type of strategy selected and

the frequency of use, suggests that the problem solver represents the problem twice. Most problem solvers used Strategy A and B which required two different representations. In such cases, an overview of the problem was established, the selection of elements was made, and the solution was obtained. This study would support Simon's hypothesis (1973), that ill-defined problems eventually become a series of well-defined problems for the problem solver. As previously indicated, all categories of problem solvers defined the problems further by adding personal criteria or focusing on highlighted criteria.

Relationship Between Solution Patterns and Dominant K.A.M.

The fourth objective of this study was to determine if a relationship exists between an individual's problem solving behaviours and his/her dominant knowledge accessing mode. These problem solving behaviours refer to the selection and introduction of criteria, solution patterns, choice and application of a strategy, and final solution.

As previously indicated, all categories of problem solvers introduced criteria to the problem definition. No association was found between the introduction of criteria and the dominant knowledge accessing mode. However, it was observed that most criteria were introduced after the elements of the problem had been reviewed.

No association was found between the number of steps required to solve the problems and dominant knowledge accessing modes. In relation to the pattern of steps, the majority of problem solvers used the same number of steps to solve each of their three problems or displayed a decreasing pattern in the number of steps required to solve their first problem to their last problem.

An association between the time required to solve the problems and dominant knowledge accessing mode was found. A different pattern, in regards to time was obtained by noetic problem solvers. In relation to the pattern of time, the majority of problem solvers did not display an increasing time pattern nor a decreasing time pattern from their first problem solved to their last.

An association was found between strategies of solution and dominant knowledge accessing mode. Strategy A was found to be distinct and a different pattern was obtained by empirical problem solvers while using this strategy.

In regards to the actual selection of mini scenarios compatible with dominant knowledge accessing mode, an association was found between agreement and dominant knowledge accessing mode. A different pattern of agreement was obtained by rational problem solvers.

The above results indicate that the metacomponents (the higher order control processes used for executive planning,

monitoring and evaluating ones performance in a task) are more related to the knowledge accessing mode than the performance components (the lower order processes used to execute various strategies in task performance). The metacomponents that seem to be most important when solving selection-type, ill-defined problems are 1) selecting a strategy; 2) selecting mental representations; 3) deciding how to allocate attentional resources; and 4) monitoring or keeping track of one's place in the task performance.

A global profile of the problem solving behaviours of the problem solvers was established. The variables in this profile included: 1) the number of steps and step patterns required to solve the problems; 2) the time and time patterns required; 3) the strategies and strategy patterns selected; 4) the type of criteria introduced to the problem definition and the patterns of introduction; and 5) the final selections and agreement patterns to the problems. The strategy chosen, total time required, and agreement patterns emerged as important components when describing the patterns of solution for the problem solvers. Table 18 presents a global profile of the the problem solving behaviours for noetic, empirical, and rational problem solvers.

Table 18

Global Characteristics
of Problem Solving Behaviours for
Noetic, Empirical, Rational Problem Solvers

Problem Solvers		
Noetic	Empirical	Rational
Required three steps for solution of problems.	Required three steps for solution of problems.	Required three steps for solution of problems.
Displayed all combinations of step patterns in problem sequence.	Displayed all combinations of step patterns in problem sequence.	Displayed all combinations of step patterns in problem sequence.
Required 13.2 minutes (average) to solve problems*.	Required 16.6 minutes (average) to solve problems.	Required 16.3 minutes (average) to solve problems.
Displayed all combinations of time patterns in problem sequence.	Displayed all combinations of time patterns in problem sequence.	Displayed all combinations of time patterns in problem sequence.
Defined problems through personal and highlighted criteria.	Defined problems through personal and highlighted criteria.	Defined problems through personal and highlighted criteria.
Introduced criteria during and after review of problem elements.	Introduced criteria during and after review of problem elements.	Introduced criteria during and after review of problem elements.
Relied primarily on reviewing problem elements before attempting a solution.	Relied primarily on reviewing problem elements before attempting solution or attempting a solution while reviewing elements*.	Relied primarily on reviewing problem elements before attempting a solution.
Displayed all combinations of strategy use in problem sequence.	Displayed all combinations of strategy use in problem sequence.	Displayed all combinations of strategy use in problem sequence.
Selected noetic, empirical, rational responses.	Selected noetic, empirical, rational responses.	Selected noetic, empirical, rational responses.
Displayed all combinations of agreement patterns.	Displayed all combinations of agreement patterns.	Displayed all combinations of agreement patterns*.

*Indicates a different pattern was observed.

Future Research

From a research point of view, this study raised many questions to be considered for future research. These questions are as follows. Can the strategies for solution be further defined? What other factors contribute to the relationship between the knowledge accessing mode of the problem solver and problem solving behaviours? How does a problem solver represent the problem, specifically? Can the metacomponents and the performance components be further defined? What are the implications of the time component in regards to the problem solving behaviours? Is there any transfer of learning? How do problem solving behaviours develop and change over one's life span? Are the problem solving behaviours used by experts the same as those employed by novices?

This study generated an exuberant amount of data. More in-depth research specific to each category of problem solver should be conducted, as well as research pertaining to each of the problems. To obtain stable estimations of relevant parameters, a similar study should be conducted with a larger sample size.

Specifically, time emerged as an important component to the problem solving behaviour. This component needs to be addressed more thoroughly. Studying selection-type, ill-defined problems and applying a time constraint, as witnessed in many employment situations, may result in different types of strategies being utilized.

Implications for Education

On a practical note, if the purpose of the school system is to help each student develop his/her potential as an individual and as a contributing, responsible member of society who will think clearly, feel deeply, and act wisely (Ministry of Education, 1984); then educators are responsible for helping each student acquire skills that contribute to self reliance in solving practical problems in everyday life. If our educational system continues to focus on the mastery of facts and procedures, teachers and students alike will experience difficulty developing the higher-order problem solving skills necessary for solving everyday problems.

By applying the principles of information processing to education and understanding the dynamics of problem solving, educators may now begin to comprenend how people process information in learning situations. In so doing, an enhanced understanding of the strategies people make use of to solve problems would evolve. Knowledge of the use of strategies is, therefore, pertinent to education. If individuals are indeed using strategies, it should be known what they are and why they are used. With this information, the educational system could provide direct instruction on such strategies and, then, comprehensive methods of general problem solving could be developed and taught. From the standpoint of educational policy, it would be desirable to determine the teach-ability of teaching

problem solving. Achievement of this objective is one of the reasons research in the problem solving area is crucial.

From a research perspective, many critics decry the quality of educational research, however, few provide useful suggestions for its' improvement. Educational research needs to establish a research methodology explicit unto itself that addresses the specific concerns of education. In most research (educational research not excluded) the focus has been on the product (finding a result). In contrast, this research has focused upon the process, the means by which the products are achieved. It is felt, that if some processes prove more beneficial than others in terms of final outcome, then a closer evaluation of these processes seems justified. This research indicates that such patterns and processes can be identified and, in so doing, raises many questions for further educational research.

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APPENDIX A

Selection-Type, Ill-Defined Problems

Task Problem
Which Learning Task Would You Choose?

You are a teacher registered in a 'Curriculum Design' course for adult education at the local university. This course is offered by the Faculty of Education and lasts for one semester (thirteen weeks), one night per week, for three hours. On successful completion of this course, you will receive an increase in salary and a possible promotion. On the first night of the course the professor hands out the course outline and a sheet of paper describing nine learning tasks. Your professor announces that there is one required text book and that your final evaluation will be based on the completion of three learning tasks. Your professor explains that the text book is approximately three hundred and fifty pages and is divided into ten chapters. It contains current content, is well organized, and integrates principles with application. Your professor explains that you must choose three learning tasks from the list of nine learning tasks which has been distributed. Your professor wants you to make your choices immediately and to register your choices with him/her. Once you have made your decisions, they will hold firm for the term. This is the only information provided by your professor. Your professor leaves the room to give you time to decide which three learning tasks you would choose. Defend your choice.

1. Written chapter summaries: intended for personal use and should be practical and realistic; each summary no longer than 500 words per chapter; the summaries are to emphasize content and personal observations; the task will be satisfactorily completed if the summaries are expressed succinctly, proceed from particular instances or cases to a general conclusion, and reflect your personal observations; the task is designed to provide you with the opportunity to focus on the facts as well as your own experiences. (Empirical)

2. Personal reaction paper to one of the ideas expressed in the book: intended for submission to a local radio station which is putting together a panel of experts to discuss adult education; no longer than 1000 words; the task will be satisfactorily completed if the reaction paper is original, creative, synthesizes the main concept, and expresses a personal opinion; the task is designed to provide you with the opportunity to be creative and to express your feelings. (Noetic)

3. Illustrated chapter summaries, flow charts or diagrams capturing the information in each chapter: intended for distribution to class members so they can use them to make overheads for their own presentations should they wish; each chapter illustration, flow chart, or diagram will cover one regular size sheet of paper per chapter; the task will be satisfactorily completed if the diagrams show a logical flow from a general premise to a specific conclusion; the task is designed to provide you with the opportunity to organize your thoughts in a logical manner. (Rational)

4. Text book review: intended for publication or presentation to a journal which is interested in reviewing current text books; no longer than 1000 words; the task will be satisfactorily completed if the book review is a concrete reflection of the content contained in the book; facts are to be highlighted; the task is designed to provide you with the opportunity to observe things as they are. (Empirical)

5. Poster presentation of the book: intended for presentation at an adult education workshop; no larger than two sheets of bristol board; the task will be satisfactorily completed if the presentation is aesthetically pleasing and synthesizes the information contained in the book; the task is designed to provide you with the opportunity to express your own personality. (Noetic)

6. Five ideas for mini research projects: intended for presentation to the class to generate exchange on their feasibility; to be presented in written form; these research projects are to be developed from ideas expressed in the book; no longer than 500 hundred words each; the task will be satisfactorily completed if the research projects are realistic and allow for observation; the task is designed to provide you with the opportunity to explore empirical methods of research. (Empirical)

7. Evaluate the validity of the author's position: intended for presentation to a curriculum committee evaluating text books; the task will be satisfactorily completed when you write a valid critique of the author's ideas; this critique should focus on the synthesis of the material contained in the book; the task is designed to provide you with the opportunity to think and to be stimulated by ideas. (Rational)

8. Annotated bibliography: intended for distribution to class members who are interested in generating a current reference list; the task will be satisfactorily completed when you hand in five critical or explanatory citations to explain further some phenomenon found in the book; each reference will be accompanied by a logically written synopsis; the task is designed to provide you with the opportunity to test your comprehension and critical thinking ability. (Rational)

9. Practical implications of the book: intended for presentation to a group of teachers involved in adult education; no longer than 1000 words; the task will be satisfactorily completed when you synthesize the book by expanding on how the book can be applied at a practical level; the task is designed to provide you with the opportunity to express your ideas, show your personal reactions, and to be creative. (Noetic)

Interview Problem

Who Would You Interview?

You have the opportunity to sit on a committee to help select one candidate from nine to be hired for one full time position available in your school. Your school is looking for someone to teach a variety of subjects offered as part of the Social Science curriculum. The school's main concern is to hire a teacher possessing a distinct teaching style. In addition to the regular application forms, applicants for the position were asked to submit two letters of reference. These letters were to outline objectively and subjectively the applicant's teaching method. Nine applicants made the short list. Criteria for the short list selection were based on the applicant's dossier and intuition that the candidate would be an asset to the school. Content from each of the candidate's dossier was summarized. The administration would like to interview all nine candidates. However, because of time restrictions, this can not be done. The hiring committee only has time to interview three people. Your only information is that which has been presented to you. You must decide which three candidates should be interviewed and defend your choice to the committee.

1. Teacher N.B.: male; 24 years old; English Canadian; he teaches by lecturing; his lectures are well organized and brimful of pertinent information; he presents the macro picture before he presents the micro picture; he does not always encourage questions or open discussion; he seems to be aloof and detached from his students; his teaching method does not vary; his students listen, take notes, and read the assigned readings; his tests evaluate critical thinking abilities; his class average is 71%; his letters of reference are from his practice teaching experiences; he is rated as an exceptional teacher; he is described as being a person who lives by his principles; his curriculum vitae was done professionally. (Rational)

2. Teacher M.A.: female; 37 years old; French Canadian; speaks English with an accent; she teaches using a question and answer method; she expects students to come to class willing to talk and to share their experiences; she is impulsive and has an independent mind; at times she gets off track but the discussions are interesting; she likes students who present original ideas; her tests evaluate creativity and personal reactions; she puts her marks on a bell curve; she is described as being a person who trusts her own feelings; her application was hand written and her curriculum vitae was five years old. (Noetic)

3. Teacher J.R.: female; 40 years old; English Canadian; she teaches by writing notes on the black board and students are encouraged to copy these notes; the notes are straight forward, well organized, and detailed; her presentation moves from particular situations to global situations; she has little tolerance for the unconventional; she will frequently stop her presentation to give a realistic example or demonstration; her tests and exams evaluate facts and observation skills; her class average is 69%; she enclosed a picture with her application and she looks serious and reserved; she is described as being realistic, a person who is down-to-earth and observant. (Empirical)

4. Teacher G.D.: male; 43 years old; European; speaks English with an accent; he teaches by encouraging his students to discuss their ideas; he stresses creativity and originality in thought, it is the idea that is being challenged and not the individual; he is not as interested in content as he is in the process; occasionally he will synthesize the discussion; his tests and exams force the student to think and to give his/her personal reaction to ideas; he is described as being attentive to the needs of others; his class average is 68%; his curriculum vitae does not account for a three year period. (Noetic)

5. Teacher K.T.: female; 26 years old; English Canadian; she teaches using related exercises which tend to emphasize observation; she will first present material in a mini-lecture and follow this lecture with an exercise that encompasses what was just taught; there is limited time for questions and discussion; her lectures and exercises are well organized, objective, and detailed; her tests evaluate knowledge of facts; her class average is 70%; her letters of reference rate her as an exceptional teacher; she is described as being practical and realistic. (Empirical)

6. Teacher S.M.: male; 37 years old; British; he teaches using audio-visual aids; he makes use of films in order to present a global perspective, and then follows the film with a lecture and a discussion on particular aspects of the global picture; he is tough minded and will accept your view point if it is logical and analytical; his tests and exams are challenging and evaluate critical thinking abilities (comprehension); his class average is 64%; he is described as being trustworthy, a person you can count on; his dossier is minus one letter of reference. (Rational)

7. Teacher P.F.: female; 48 years old; her teaching method is to stress independent study; she does not have much time for the conventional techniques; she encourages her students to set up independent studies that are alternative to the mainstream; all communication is between the student and herself; she sees herself as a nontraditional resource person; her evaluation of students is based on creativity and personal reactions; her class average is 75%; her letters of reference indicate that her independent studies are well monitored; she sees education as a process of self discovery. (Noetic)

8. Teacher Y.C.: female; 32 years old; she believes that you learn by doing; her classes are labs or exercises where inductive reasoning is stressed (particular to general); her labs and exercises are traditional and well researched; each lab or exercise handed in is extensively critiqued; her final evaluation is based on the labs and exercises and tests knowledge of facts and observation skills; her class average is 69%; her letter of application states that her husband has been recently transferred to the area and she is looking for full time employment; she is described as a person who bases her opinions on facts and/or observations. (Empirical)

9. Teacher D.D.: male; 52 years old; he teaches by using exercises that are done in small groups; his exercises are somewhat abstract and present a major premise; the group must work cooperatively defining minor premises and arrive at a conclusion; at the end of the class the other groups will prove or disprove each other's work utilizing the rules of logic; his marking system is based on group effort, and based on how the students rate each other; he looks for critical thinking abilities; his class average is 65%; his dossier is complete; he is described as a person who lives by his principles. (Rational)

Award Problem

Who Would You Choose to be Award Winners?

You are on the Board of Governors of a local post secondary institution. At the termination of each year, the board chooses three teachers each to receive an 'Outstanding Teacher' award. The criteria for selection are not clearly defined. However, the purpose of the award is to recognize three teachers' unselfish contributions to teaching and the school environment. In a general discussion several important characteristics required by the recipients were discussed: honesty, trustworthiness, enthusiasm, effectiveness as a teacher, involvement in extracurricular activities, willingness to help others, genuineness, and positive attitude. You have been asked to be a member of the selection committee to decide which three teachers should receive the awards for this year. The choice has been narrowed to nine candidates. This is the only information you have. Which three would you choose? Defend your choice to the committee.

1. Teacher I.R.: male; 28 years old; English Canadian; he has taught drama and English at the school for four years; he has established the first theatre group and has put on the first school production which was open to the public, it was a success; he is described as being spontaneous (creative - insightful); his tests evaluate creativity and personal reactions; he is always available for extra help. (Noetic)

2. Teacher D.E.: female; 65 years old; British; she is retiring from teaching this year; she has been teaching English at the school for 35 years; she presents a well structured course; she has been strict but fair; she is somewhat aloof and detached; she has done a tremendous amount of work to improve the quality of the library facilities at the school; recently she has computerized the library system; she describes her teaching career as being an intellectual challenge, an opportunity to work with ideas. (Rational)

3. Teacher P.P.: male; 49 years old; English Canadian; he was a former student at the school; he went to university and received his education in physical education; he returned to his school and was hired as the physical education teacher for his school; he has held this position for 25 years; he is resigning from teaching to go into a hardware business; although tough minded he has done much to improve the school spirit through sport; he established and coached three winning teams, girls basketball, boys football, and boys and girls badminton; he is described as being logical, a person who follows principles and rules. (Rational)

4. Teacher A.H.: male; 60 years old; European; speaks English with an accent; he has taught biology at the school for 30 years; he is retiring; he established an outdoor education centre for the school and the community; this centre has been recognized by the Ministry of Education and written up as a model for other schools to emulate; he is described as being realistic a person who is down-to-earth and observant. (Empirical)

5. Teacher S.C.: female; 37 years old; English Canadian; has taught physical education part time and has been a guidance counsellor the rest of the time; she has been at the school for 13 years; she has done much to make the student service centre more available to the students; students and colleagues speak highly of her logical, analytical ability; last year she won the citizen award for community volunteer work. (Rational)

6. Teacher M.T.: female; 52 years old; Chinese; she speaks English with an accent; has been at the school for 27 years; she quietly goes about her teaching responsibilities in physics; students describe her as being a tough teacher but the best there is; they say that when you leave her classes you really know the subject; she is always available for extra help; she is patient; she makes you earn your marks and when you do you feel proud of yourself; she is described as a person who can adjust to situations as they arise. (Empirical)

7. Teacher J.V.: female; 48 years old; French Canadian; speaks English with an accent; has been at the school for 19 years; teaches art; she believes in the open door policy, in other words, the art room is always open for students to come in and experiment with their own creativity; she always takes the time to help and to listen; for the last 10 years she has orchestrated the annual student art show; this show has been recognized by the art community as being an event worth attending; she is described as being dynamic and active. (Noetic)

8. Teacher B.L.: male 49 years old; French Canadian; speaks English with an accent; has been at the school for 20 years; he is a good geography teacher; he has spent much time organizing student activities such as trips to Europe, biking weekends, outdoor camping weekends, skiing weekends; he does this on his own time and frequently uses his own money; parents have felt secure in allowing their children to attend these trips since they are well organized, educational, and safe; he is described as being practical and realistic. (Empirical)

9. Teacher F.W.: male; 34 years old; Canadian Indian; has been at the school teaching sculpturing for 10 years; he is sick with a terminal disease; recently he was commissioned by the city to design a sculpture to be placed in front of a government building; he started the sculpturing program at the school; he has been described as being intuitive, a person who is creative and spontaneous; he has done much to encourage students and in particular native students to further their education. (Noetic)

APPENDIX B

Semi-Directed Focused Interview

THE EDUCATIONAL PROBLEM OPINIONNAIRE

List the following on the cassette label before the interview.

Name of Interviewee _____

Position _____

Date _____

Name of Institution _____

The University of Ottawa and myself are working cooperatively to identify educationally relevant problems. These problems must have a sufficient number of elements to allow for alternative solutions. We are interested in studying the processes and patterns that people exhibit as they solve complex ill-defined problems.

You are actively involved in education and therefore I am asking you to solve five problems and then to critically evaluate the content by verbally responding to a Semi-Directed Focused Interview. I would appreciate the opportunity to record your solution attempt and to record your observations and feelings on the problem scenarios you solve. Please be generous with your information. Confidentiality is guaranteed.

Problem 1. AWARD WINNERS - STUDENTS

Problem 2. AWARD WINNERS - TEACHERS

Problem 3. HIRING STAFF MEMBERS

Problem 4. EVALUATION PROCEDURES

Problem 5. LEARNING STRATEGIES

PROBLEM NUMBER _____

1. Is the problem representative of a problem encountered in education? Please explain.

2. Did you feel you needed to add something to the problem in order to solve it? Please explain.

3. Did your personal values influence your solution to the problem? Please explain.

4. Did you find that you changed your mind the more you became involved with the problem? Please explain.

5. Was the content of the problem familiar to you? Please explain.

6. Did you find the problem too general? Please explain.

7. Did the problem have a sufficient number of elements to allow for alternative solutions? Please explain.

8. Did you find that you focused on a few elements of the problem while neglecting other elements? Please explain.

9. Can you identify some additional criteria you used or applied to the solution of the problem? Please explain.

10. Overall, how would you rate this problem?

Please rank order the problems in terms of relevancy to education. Number 1 will represent the most relevant problem.

The following questions are personal in nature. I would appreciate your honest answers. Anonymity is guaranteed.

1. Are you presently employed in education?

2. If you are, what is your position? Please describe it briefly.

3. How long have you been in education?

4. What is your educational level?

5. Did you receive your education in Canada?

6. If not, where were you educated?

Are there are any additional comments you would like to make about the problems?

APPENDIX C

Practice Problem

Dog and Food Matching

There are four dogs sitting in front of their dog houses. The dogs, in left to right order, are Pizza, Tiger, Lady, and Sancho. Based on the information given below, figure out which dog eats Crunchy Blend dog food.

1. Pizza lives in a blue dog house.
2. The dog who lives in a red house eats Yummies.
3. Sancho eats Butcher Boy dog food.
4. Lady lives next to the dog with the green house.
5. Tiger lives next to the dog who eats Crunchy Blend.
6. The dog in the white house is next to the dog who eats Butcher Boy.
7. The dog who eats medium rare steak is farthest away from the dog who eats Butcher Boy.

* MAKE SURE YOU SAY OUT LOUD EVERYTHING THAT COMES TO YOUR MIND. EXPLAIN WHY YOU DO THINGS AND HOW YOU DO THEM.

APPENDIX D

Coded Protocol

Scored Protocol for a Rational Female Solving the 'Interview Problem'

Code	Line	Protocol
Planning Statement	1	Ok, I'll read the problem through.
Read Main Scenario	2-25	You have the opportunity to sit on a committee to help select one candidate from nine to be hired for one full time position available in your school. Your school is looking for someone to teach a variety of subjects offered as part of the Social Science curriculum. The school's main concern is to hire a teacher possessing a distinct teaching style. In addition to the regular application forms, applicants for the position were asked to submit two letters of reference. These letters were to outline objectively and subjectively the applicant's teaching method. Nine applicants made the short list. Criteria for the short list selection were based on the applicant's dossier and intuition that the candidate would be an asset to the school. Content from each of the candidate's dossier was summarized. The administration would like to interview all nine candidates. However, because of time restrictions, this can not be done. The hiring committee only has time to interview three people. Your only information is that which has been presented to you. You must decide which three candidates should be interviewed and defend your choice to the committee.
Restated Task	26	I'm selecting candidates to be interviewed.
	27	I have to select three.
Observation Statement	28	I teach psychology in social sciences, so I have a feel of what to look for.

Planning Statement	29	I think I'll read through all my choices first.

End of Step 1 Time: 2.1 minutes

Step 2: Initial Review of Mini Scenarios

Considered nine mini scenarios 30-115

1. Teacher N.B.: male; 24 years old; English Canadian; he teaches by lecturing; his lectures are well organized and brimful of pertinent information; he presents the macro picture before he presents the micro picture; he does not always encourage questions or open discussion; he seems to be aloof and detached from his students; his teaching method does not vary; his students listen, take notes, and read the assigned readings; his tests evaluate critical thinking abilities; his class average is 71%; his letters of reference are from his practice teaching experiences, he is rated as an exceptional teacher; he is described as being a person who lives by his principles; his curriculum vitae was done professionally.

2. Teacher M.A.: female; 37 years old; French Canadian; speaks English with an accent; she teaches using a question and answer method; she expects students to come to class willing to talk and to share their experiences; she is impulsive and has an independent mind; at times she gets off track but the discussions are interesting; she likes students who present original ideas; her tests evaluate creativity and personal reactions; she puts her marks on a bell curve; she is described as being a person who trusts her own feelings; her application was hand written and her curriculum vitae was five years old.

3. Teacher J.R.: female; 40 years old; English Canadian; she teaches by writing notes on the black board and students are encouraged to copy these notes; the notes are straight forward, well organized, and detailed; her presentation moves from particular situations to global situations; she has little tolerance for the unconventional; she will frequently stop her presentation to give a realistic example or demonstration; her tests and exams evaluate facts and observation skills; her class average is 69%; she enclosed a picture with her application and she looks serious and reserved; she is described as being realistic, a person who is down-to-earth and observant.

4. Teacher G.D.: male; 43 years old; European; speaks English with an accent; he teaches by encouraging his students to discuss their ideas; he stresses creativity and originality in thought, it is the idea that is being challenged and not the individual; he is not as interested in content as he is in the process; occasionally he will synthesize the discussion; his tests and exams force the student to think and to give his/her personal reaction to ideas; he is described as being attentive to the needs of others; his class average is 68%; his curriculum vitae does not account for a three year period.

5. Teacher K.T.: female; 26 years old; English Canadian; she teaches using related exercises which tend to emphasize observation; she will first present material in a mini-lecture and follow this lecture with an exercise that encompasses what was just taught; there is limited time for questions and discussion; her lectures and exercises are well organized, objective, and detailed; her tests evaluate knowledge of facts; her class average is 70%; her letters of reference rate her as an exceptional teacher; she is described as being practical and realistic.

6. Teacher S.M.: male; 37 years old; British; he teaches using audio-visual aids; he makes use of films in order to present a global perspective, and then follows the film with a lecture and a discussion on particular aspects of the global picture; he is tough minded and will accept your view point if it is logical and analytical; his tests and exams are challenging and evaluate critical thinking abilities (comprehension); his class average is 64%; he is described as being trustworthy, a person you can count on; his dossier is minus one letter of reference.

7. Teacher P.F.: female; 48 years old; her teaching method is to stress independent study; she does not have much time for the conventional techniques; she encourages her students to set up independent studies that are alternative to the mainstream; all communication is between the student and herself; she sees herself as a nontraditional resource person; her evaluation of students is based on creativity and personal reactions; her class average is 75%; her letters of reference indicate that her independent studies are well monitored; she sees education as a process of self discovery.

8. Teacher Y.C.: female; 32 years old; she believes that you learn by doing; her classes are labs or exercises where inductive reasoning is stressed (particular to general); her labs and exercises are traditional and well researched; each lab or exercise handed in is extensively criticized; her final evaluation is based on the labs and exercises and tests knowledge of facts and observation skills; her class average is 69%; her letter of application states that her husband has been recently transferred to the area and she is looking for full time employment; she is described as a person who bases her opinions on facts and/or observations.

9. Teacher D.D.: male; 52 years old; he teaches by using exercises that are done in small groups; his exercises are somewhat abstract and present a major premise; the group must work cooperatively defining minor premises and arrive at a conclusion; at the end of the class the other groups will prove or disprove each other's work utilizing the rules of logic; his marking system is based on group effort, and based on how the students rate each other; he looks for critical thinking abilities; his class average is 65%; his dossier is complete; he is described as a person who lives by his principles.

Observation Statements	116	Ok, this is just for an interview.
	117	That means that what is in the resume may not really be what you get.
	119	People can make resumes sound really good, but when you meet the person you get a different feeling.
	120	Also, if push came to shove, and the three candidates that are brought in for an interview do not measure up, time would have to be found to interview more, n'est ce pas?

End of Step 2 Time: 7.3 minutes

Step 3: Second Review of Mini Scenarios

Planning Statement	121	So, I guess I'm going to look at each candidate to see what I think.

Considered 122-145
Mini Scenario

1. Teacher N.B.: male; 24 years old; English Canadian; he teaches by lecturing; his lectures are well organized and brimful of pertinent information; he presents the macro picture before he presents the micro picture; he does not always encourage questions or open discussion; he seems to be aloof and detached from his students; his teaching method does not vary; his students listen, take notes, and read the assigned readings; his tests evaluate critical thinking abilities; his class average is 71%; his letters of reference are from his practice teaching experiences, he is rated as an exceptional teacher; he is described as being a person who lives by his principles; his curriculum vitae was done professionally.

Addressed
Mini Scenario:

Added Criterion	146	Number 1, well he is young, I think age is important to consider. That means you may be able to mould him and he's got room for development.
	147	He may be lecturing because that's what his associate teacher wanted.
Positive Appraisal	148	He may be ok, I may consider him.

Considered 149-161
Mini Scenario

2. Teacher M.A.: female; 37 years old; French Canadian; speaks English with an accent; she teaches using a question and answer method; she expects students to come to class willing to talk and to share their experiences; she is impulsive and has an independent mind; at times she gets off track but the discussions are interesting; she likes students who present original ideas; her tests evaluate creativity and personal reactions; she puts her marks on a bell curve; she is described as being a person who trusts her own feelings; her application was hand written and her curriculum vitae was five years old.

Addressed Mini Scenario:

Restated Added Criterion 162 Number 2, she still has age on her side.

Included a Mini Scenario 163 I would like to interview her to see if I could change her mind about the bell curve.

Positive Appraisal 164 I like her approach, as long as she is not too off track.

Considered Mini Scenario 165-178

3. Teacher J.R.: female; 40 years old; English Canadian; she teaches by writing notes on the black board and students are encouraged to copy these notes; the notes are straight forward, well organized, and detailed; her presentation moves from particular situations to global situations; she has little tolerance for the unconventional; she will frequently stop her presentation to give a realistic example or demonstration; her tests and exams evaluate facts and observation skills; her class average is 69%; she enclosed a picture with her application and she looks serious and reserved; she is described as being realistic, a person who is down-to-earth and observant.

Addressed Mini Scenario:

Negative Appraisal 179 Well, I'm not too keen on the notes.

180 I can picture some of my teachers who were note writers, and sure it gave me something to do during class but, I ask you, at this age?

Considered Mini Scenario 181-193

4. Teacher G.D.: male; 43 years old; European; speaks English with an accent; he teaches by encouraging his students to discuss their ideas; he stresses creativity and originality in thought, it is the idea that is being challenged and not the individual; he is not as interested in content as he is in the process; occasionally he will synthesize the discussion; his

tests and exams force the student to think and to give his/her personal reaction to ideas; he is described as being attentive to the needs of others; his class average is 68%; his curriculum vitae does not account for a three year period.

Addressed Mini Scenario:

Included a Mini Scenario 194 I would like to interview this guy just to see how laid back he is.

195 I like his ideas, emphasizing process.

Considered Mini Scenario 196-207

5. Teacher K.T.: female; 26 years old; English Canadian; she teaches using related exercises which tend to emphasize observation; she will first present material in a mini-lecture and follow this lecture with an exercise that encompasses what was just taught; there is limited time for questions and discussion; her lectures and exercises are well organized, objective, and detailed; her tests evaluate knowledge of facts; her class average is 70%; her letters of reference rate her as an exceptional teacher; she is described as being practical and realistic.

Addressed Mini Scenario:

Negative Appraisal 208 I don't no.

209 It sounds like here's the stuff, now do this; here's more stuff, now do this.

210 When does it get pulled together?

Considered Mini Scenario 211-222

6. Teacher S.M.: male; 37 years old; British; he teaches using audio-visual aids; he makes use of films in order to present a global perspective, and then follows the film with a lecture and a discussion on particular aspects of the global picture; he is tough minded and will accept your view point if it is logical and analytical; his tests and exams are challenging and evaluate critical thinking abilities (comprehension);

his class average is 64%; he is described as being trustworthy, a person you can count on; his dossier is minus one letter of reference.

Addressed Mini Scenario:

Negative Appraisal

223 Well, I'm not keen on films, there is so much A.V. with TV, etc.

224 I don't know, it sounds as if he is lazy.

225 I don't know where he would get current films.

226 We do not have an extensive budget for film rental

Considered Mini Scenario 227- 239

7. Teacher P.F.: female; 48 years old; her teaching method is to stress independent study; she does not have much time for the conventional techniques; she encourages her students to set up independent studies that are alternative to the mainstream; all communication is between the student and herself; she sees herself as a nontraditional resource person; her evaluation of students is based on creativity and personal reactions; her class average is 75%; her letters of reference indicate that her independent studies are well monitored; she sees education as a process of self discovery.

Addressed Mini Scenario:

Negative Appraisal

240 No, this is a little too much for me.

241 How can she monitor them?

242 In social science she could be responsible for 100 students.

Considered Mini Scenario 243-256

8. Teacher Y.C.: female; 32 years old; she believes that you learn by doing; her classes are labs or exercises where inductive reasoning is stressed (particular to general); her labs and exercises are traditional and well researched; each lab or exercise

handed in is extensively criticised; her final evaluation is based on the labs and exercises and tests knowledge of facts and observation skills; her class average is 69%; her letter of application states that her husband has been recently transferred to the area and she is looking for full time employment; she is described as a person who bases her opinions on facts and/or observations.

Addressed Mini Scenario:		
Positive Appraisal	237	Hey, I like this learning by doing business.
Included a Mini Scenario	238	I would interview her to see if her exercises and labs were current.
Considered Mini Scenario	239-251	

9. Teacher D.D.: male; 52 years old; he teaches by using exercises that are done in small groups; his exercises are somewhat abstract and present a major premise; the group must work cooperatively defining minor premises and arrive at a conclusion; at the end of the class the other groups will prove or disprove each other's work utilizing the rules of logic; his marking system is based on group effort, and based on how the students rate each other; he looks for critical thinking abilities; his class average is 65%; his dossier is complete; he is described as a person who lives by his principles.

Addressed Mini Scenario:		
Negative Appraisal	252	Group work, give me a break!
	253	At this level?
Observation Statement	254	So let's see,
	255	I would interview number 1, number 2, number 4, number 8.
Restated Task	256	Now I have to pick three.

End of Step 3 Time: 10.3 minutes

Step 4: Third Review of Mini Scenarios

Considered Mini Scenario		
Restated Added Criterion and Included a Mini Scenario	257	Well, I think I will go for youth, number 1.
Considered a Mini Scenario		
Included a Mini Scenario	258	I'll take number 2, for generating ideas.
Reconsidered two Mini Scenarios	259	Now it's between number 4 and number 8
Addressed two Mini Scenarios		
Restated Added Criterion	260	Number 4 is older.
	261	Therefore more experienced.
Observation Statement	262	Number 8 will likely be around for awhile, because her husband has been transferred.
Positive Appraisal	263	I like the idea of making students think (number 4).
Decision to Include and Exclude a Mini Scenario	264	I think I will choose 4 over 8
Observation Statements	265	My choices are number 1, number 2, and number 4.
	266	I recognize the fact that if I don't like any of them in person, I will have to return to the files and perhaps we will have to advertise again.

End of Step 4 Time: 1.6 minutes

Total Time of Protocol: 21.3 minutes

APPENDIX E

Steps and Time* Required to Solve the 'Task Problem' by Each Category of Problem Solver

Subject Number	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Total Time
Noetic Males (ID):							
41	2.2	8.7	1.5				12.4
48	2.0	4.6	0.2				6.8
23	2.2	8.5	0.2				10.9
31	2.8	1.7	5.4	3.2	6.6	0.2	19.9
37	1.8	6.6	1.2				10.2
14	1.8	3.7	1.9				7.4
13	2.0	6.1	0.1				8.2
42	2.4	7.2	9.6	2.3	0.3		21.8
Noetic Females (ID):							
32	2.4	11.5	3.4	1.6			18.9
40	2.9	6.7	3.5				13.1
36	2.6	4.5	2.0				9.1
39	2.0	7.3	1.5	0.9			11.7
25	2.5	3.7	3.4				9.6
10	2.5	7.4	1.3				11.1
38	2.3	5.0	3.6				10.9
24	2.6	6.6	1.6				10.7
Empirical Males (ID):							
7	2.1	4.5	1.9				8.5
2	2.0	9.5	5.4	7.2	0.4		24.5
11	1.6	12.9	5.4	3.5			23.4
19	4.3	11.5	2.7				18.5
12	1.2	5.6	3.5				10.3
16	4.5	12.5	1.7				18.7
21	1.6	5.3	2.1				9.0
1	4.6	8.6	1.4				14.6
Empirical Females (ID):							
5	2.6	6.0	5.0	0.8			14.4
18	2.7	6.5	6.4				15.6
4	2.5	6.7	2.1				11.3
20	5.4	8.3	2.7	3.7			20.1
30	2.0	5.4	2.8				10.2
27	2.5	9.2	1.4				13.2
33	1.2	8.3	3.2				12.7
15	2.2	3.4	0.6				6.2

Table (continued)

Subject Number	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Total Time
Rational Males (ID):							
47	2.9	4.9	1.5				9.3
29	2.5	5.9	5.5	1.4			15.3
26	2.3	9.1	9.3	5.2			25.9
44	2.2	7.5	7.0				16.7
8	2.1	1.5	4.1	12.9			20.6
22	2.3	7.3	1.2				10.8
45	1.4	3.7	0.6				5.7
46	2.4	4.1	3.3				9.8
Rational Females (ID):							
43	1.9	5.0	5.3	1.7			13.9
34	1.8	3.9	2.0				7.7
17	1.8	4.4	1.9	3.5	2.3		13.9
3	2.6	4.6	2.9				9.1
9	3.3	5.9	2.2				11.4
35	2.1	7.3	2.0				11.4
28	3.4	9.0	2.4				14.8
6	1.8	4.4	3.1				9.3

*Time expressed in minutes.

Steps and Time* Required to Solve the 'Interview Problem' by Each Category of Problem Solver

Subject Number	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Total Time
Noetic Males (ID):							
41	1.5	12.0	1.2				14.7
48	2.0	4.0	1.0	0.5			7.5
23	2.6	10.1	4.9				17.6
31	1.5	3.4	1.3	3.4	7.8	2.3	19.7
37	2.1	15.3	7.0	3.2			27.6
14	2.7	7.1	4.5				14.3
13	2.5	9.4	4.0				15.9
42	1.3	6.2	8.8				16.3
Noetic Females (ID):							
32	2.5	10.9	3.9	2.0			19.3
40	3.6	7.3	1.0	1.5			13.4
36	3.3	4.6	6.4	3.8			18.1
39	1.6	8.7	1.6				11.9
25	3.3	5.6	2.0	2.1			13.0
10	2.9	18.5	1.1				22.6
38	2.0	4.7	2.5	0.5			9.7
24	1.7	6.1	2.3				10.1
Empirical Males (ID):							
7	2.0	5.3	2.7				10.0
2	1.2	6.3	11.5	2.1			21.1
11	3.5	8.7	15.0	3.7	1.5		32.4
19	2.2	22.9	10.0	10.1			45.2
12	2.0	8.7	2.0	3.1			17.8
16	2.2	9.2	2.1				13.5
21	2.0	4.0	1.0				7.0
1	2.7	11.7	2.5				16.9
Empirical Females (ID):							
5	4.0	6.0	5.8	5.7			21.5
18	1.6	10.3	7.2	3.3			22.6
4	2.6	9.9	2.4				14.9
20	2.0	11.2	7.8	5.3	3.1		29.4
30	1.1	5.4	7.1	7.0			20.6
27	2.1	11.6	2.0				15.7
33	3.7	17.7	17.7	7.4	5.7		34.5
15	1.1	5.9	5.4				12.3

Table (continued)

Rational Male Number	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Total Time
Rational Males (ID):							
47	2.2	6.7	6.0				14.9
29	2.3	6.0	5.2	2.2			16.7
26	2.3	11.2	14.3				27.8
44	2.3	14.4	3.5				20.2
8	1.6	5.3	4.1	7.9			18.9
22	2.3	8.2	6.4				16.9
45	2.6	25.6	0.1				28.3
46	2.5	11.5	9.1	4.0			26.9
Rational Females (ID):							
43	2.2	6.8	11.7	1.8			22.5
34	2.3	8.7	17.0	4.7			32.7
17	3.5	10.1	0.2				13.8
3	1.6	10.5	5.6	5.2	9.6		32.5
9	4.5	9.1	6.5				20.1
35	3.3	10.1	6.6				19.0
28	2.9	10.6	1.9				16.4
6	2.1	7.3	10.3	1.8	0.6		21.3

*Time expressed in minutes.

Steps and Time* Required to Solve the 'Award Problem' by Each Category of Problem Solver

Subject Number	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Total Time
Noetic Males (ID):							
41	1.3	8.5	0.4				10.2
48	1.2	4.1	2.3				7.6
23	1.3	5.3	2.5				9.1
31	1.1	2.4	2.4	4.4	0.9	0.5	11.7
37	1.8	7.1	7.0	0.3			16.2
14	1.7	3.4	2.3				7.4
13	1.2	4.9	2.5	1.0			9.6
42	1.6	4.5	5.2				11.3
Noetic Females (ID):							
32	1.4	7.3	4.3				13.0
40	2.2	7.2	1.8	2.1			13.3
36	2.2	4.5	4.9	2.1			13.7
39	1.1	4.8	2.2	3.9			12.0
25	1.1	4.4	3.8				9.3
10	8.0	13.4	5.7	3.3			30.4
38	2.0	4.1	2.9				9.0
24	1.4	4.2	1.3				6.9
Empirical Males (ID):							
7	2.0	5.6	3.6	0.5			11.7
2	1.7	7.4	6.5				15.6
11	2.0	11.6	6.0	1.3			20.9
19	2.0	7.0	0.5				9.5
12	1.3	7.2	7.2				15.7
16	1.6	6.0	2.8				10.4
21	1.7	5.4	1.1				8.2
1	2.5	13.2	2.0				17.7
Empirical Females (ID):							
5	3.7	5.7	7.1				16.5
18	2.7	11.5	2.6	5.2	3.2	0.1	25.2
4	2.0	4.6	1.6				8.2
20	2.2	14.2	9.8				26.2
30	1.3	4.8	1.8	2.1	9.2		19.2
27	1.5	6.0	0.1				7.6
33	3.4	10.3	3.7	4.9			22.3
15	1.3	4.1	3.1	2.5			11.0

Table (continued)

Subject Number	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Total Time
Rational Males (ID):							
47	1.6	5.3	8.4				15.3
29	1.4	4.0	4.3	5.6			15.3
26	3.6	9.9	6.4				19.9
44	1.3	4.5	1.8				7.6
8	1.3	6.0	3.4				9.1
22	1.3	6.1	2.0				9.7
45	1.3	6.0	0.8				8.1
46	1.2	5.4	2.3				8.9
Rational Females (ID):							
43	2.1	8.0	14.0				24.1
34	1.5	10.6	6.5				18.6
17	1.3	7.0	0.4				8.7
3	1.8	9.6	4.4	7.1			22.9
9	1.3	6.8	4.1				12.2
35	2.6	6.2	2.7				11.5
28	2.0	9.0	6.9				17.9
6	2.0	6.0	9.4				17.4

*Time expressed in minutes.

APPENDIX F

Pattern of Steps Required by Each Problem Solver to Solve Each Problem

Noetic M (ID):	41	48	23	31	37	14	13	42
Task Problem	3*	3	3	6*	3	3	3	5*
Interview Problem	3	4*	3*	6	4*	3*	3*	3
Award Problem	3	3	3	6	4	3	4	3
Noetic F (ID):	32	40	36	39	25	10	38	24
Task Problem	4*	3*	3	4*	3*	3	3	3*
Interview Problem	4	4	4*	3	4	3*	4*	3
Award Problem	3	4	4	4	3	4	3	3
Empirical M (ID):	7	2	11	19	12	16	21	1
Task Problem	3*	5*	4	3*	3	3*	3*	3*
Interview Problem	3	4	5*	4	4*	3	3	3
Award Problem	4	3	4	3	3	3	3	3
Empirical F (ID):	5	18	4	20	30	27	33	15
Task Problem	4	3*	3	4*	3*	3*	3	3*
Interview Problem	4*	4	3*	5	4	3	5*	3
Award Problem	3	6	3	3	5	3	4	4
Rational M (ID):	47	29	26	44	8	22	45	46
Task Problem	3*	4*	4*	3*	4	3	3	3
Interview Problem	3	4	3	3	4*	3*	3*	4*
Award Problem	3	4	3	3	3	3	3	3
Rational F (ID):	43	34	17	3	9	35	28	6
Task Problem	4*	3	5*	3	3*	3	3*	3
Interview Problem	4	4*	3	5*	3	3*	3	5*
Award Problem	3	3	3	4	3	3	3	3

* Indicates the problem each problem solver solved first.

APPENDIX G

Pattern of Total Time** Required by Each Problem Solver to Solve Each Problem

Noetic M (ID):	41	48	23	31	37	14	13	42
Task Problem	12.4*	6.8	10.9	19.9*	10.2	7.4	8.2	21.8*
Interview Problem	14.7	7.5*	17.6*	19.7	27.6*	14.3*	15.9*	16.3
Award Problem	10.2	7.6	9.1	11.7	16.2	7.4	9.6	11.3
Noetic F (ID):	**32**	**40**	**36**	**39**	**25**	**10**	**38**	**24**
Task Problem	18.9*	13.1*	9.1	11.7*	9.6*	11.1	10.9	10.7*
Interview Problem	19.3	13.4	18.1*	11.9	13.0	22.6*	9.7*	10.1
Award Problem	13.0	13.3	13.7	12.0	9.3	30.4	9.0	6.9
Empirical M (ID):	**7**	**2**	**11**	**19**	**12**	**16**	**21**	**1**
Task Problem	8.5*	24.5*	23.4	18.5*	10.3	18.7*	9.0*	14.6*
Interview Problem	10.0	21.1	32.4*	45.2	17.8*	13.5	7.0	16.9
Award Problem	11.7	15.6	20.9	9.5	15.7	10.4	8.2	17.7
Empirical F (ID):	**5**	**18**	**4**	**20**	**30**	**27**	**33**	**15**
Task Problem	14.4	15.6*	11.3	20.1*	10.2*	13.2*	12.7	6.2*
Interview Problem	21.5*	22.6	14.9*	29.4	20.6	15.7	34.5*	12.3
Award Problem	16.5	25.2	8.2	26.2	19.2	7.6	22.3	11.0
Rational M (ID):	**47**	**29**	**26**	**44**	**8**	**22**	**45**	**46**
Task Problem	9.3*	15.3*	25.9*	16.7*	20.6	10.8	5.7	9.8
Interview Problem	14.9	16.7	27.8	20.2	18.9*	16.9*	28.3*	26.9*
Award Problem	15.3	15.3	19.9	7.6	9.1	9.7	8.1	8.9
Rational F (ID):	**43**	**34**	**17**	**3**	**9**	**35**	**28**	**6**
Task Problem	13.9*	7.7	13.9*	9.1	11.4	11.4	14.8*	9.3
Interview Problem	22.5	32.7*	13.8	32.5*	20.1*	19.0*	16.4	21.3*
Award Problem	24.1	18.6	8.7	22.9	12.2	11.5	17.9	17.4

* Indicates the problem each problem solver solved first.

** Time expressed in minutes.

APPENDIX H

Pattern of Strategies Used by Each Problem Solver to Solve Each Problem

Noetic M (ID):	41	48	23	31	37	14	13	42
Task Problem	A*	A	A	A*	C.3	C.2	C.3	A*
Interview Problem	B	A*	A*	B	C.2*	A*	C.3*	B
Award Problem	A	A	A	A	B	B	C.3	C.2
Noetic F (ID):	**32**	**40**	**36**	**39**	**25**	**10**	**38**	**24**
Task Problem	B*	B*	B	C.2*	A*	C.2	A	B*
Interview Problem	B	C.2	A*	B	A	C.2*	A*	A
Award Problem	B	B	B	B	B	B	A	B
Empirical M (ID):	**7**	**2**	**11**	**19**	**12**	**16**	**21**	**1**
Task Problem	C.2*	B*	B	B*	B	B*	A*	C.2*
Interview Problem	C.2	B	B*	B	B*	C.2	A	C.2
Award Problem	C.3	B	B	B	B	B	A	B
Empirical F (ID):	**5**	**18**	**4**	**20**	**30**	**27**	**33**	**15**
Task Problem	C.2	A*	C.2	B*	C.2*	C.2*	C.2	C.2*
Interview Problem	B*	C.2	C.2*	C.2	C.2	C.2	C.2*	C.2
Award Problem	B	B	C.2	C.2	B	C.2	B	B
Rational M (ID):	**47**	**29**	**26**	**44**	**8**	**22**	**45**	**46**
Task Problem	A*	A*	B*	A*	B	C.3	C.3	A
Interview Problem	A	A	B	C.2	B*	A*	C.3*	B*
Award Problem	A	A	B	B	B	C.2	C.1	B
Rational F (ID):	**43**	**34**	**17**	**3**	**9**	**35**	**28**	**6**
Task Problem	A*	C.3	A*	C.2	C.2	B	B*	A
Interview Problem	A	C.2*	B	B*	B*	B*	B	A*
Award Problem	A	B	C.2	B	C.2	B	B	A

* Indicates the problem each problem solver solved first.

Key:
A - All Elements Reviewed
B - Elements Addressed
C.1 - Decisions to Include
C.2 - Decisions to Exclude
C.3 - Decisions to Include and to Exclude

APPENDIX I

Mini Scenarios Selected by each Problem Solver Solving each Problem

TASK PROBLEM

Sex	K.A.M.	ID	Mini Scenarios and Identified Modality								
			1 E	2 N	3 R	4 E	5 N	6 E	7 R	8 R	9 N
M	Noetic	41		2		4			7		
		48		2	3		5				
		23	1			4					9
		31		2				6		8	
		37		2			5				9
		14	1	2					7		
		13	1						7		9
		42	1		3		5				
F	Noetic	32		2				6			9
		40		2			5				9
		36	1						7		9
		39	1			4					9
		25		2			5				9
		10					5	6	7		
		38		2					7	8	
		28		2			5			8	
M	Empirical	7	1	2					7		
		2				4		6		8	
		11	1			4				8	
		19				4		6			9
		12		2		4				8	
		16	1			4				8	
		21		2					7		9
		1		2				6	7		
F	Empirical	5	1		3						9
		18						6		8	9
		4	1		3						9
		20		2				6			9
		30	1					6			9
		27	1		3						9
		33				4			7		9
		15		2		4		6			

Table (continued)

Sex	K.A.M.	ID	Mini Scenarios and Identified Modality								
			1 E	2 N	3 R	4 E	5 N	6 E	7 R	8 R	9 N
M	Rational	47	1					6			9
		29	1		3				7		
		26	1		3						9
		44			3	4		6			
		8				4		6		8	
		22	1	2							9
		45	1	2		4					
		46	1					6	7		
F	Rational	43		2					7		9
		34			3				7		9
		17		2				6			9
		3		2					7		9
		35			3				7		9
		9			3					8	9
		28			3			6		8	
		6	1				5				9

INTERVIEW PROBLEM

Sex K.A.M.	ID	Mini Scenarios and Identified Modality								
		1 R	2 N	3 E	4 N	5 E	6 R	7 N	8 E	9 R
Noetic Males	41		2				6		8	
	48							7	8	9
	23			3				7	8	
	31		2		4			7		
	37		2		4			7		
	14	1					6	7		
	13		2				6	7		
	42					5	6		8	
Noetic Females	32				4			7	8	
	40		2		4			7		
	36	1						7		9
	39		2			5			8	
	25				4				8	9
	10					5	6			9
	38					5			8	9
	24	1			4			7		
Empirical Males	7		2				6			9
	2				4	5		7		
	11						6	7		9
	19	1	2			5				
	12				4	5			8	
	16						6	7	8	
	21	1				5	6			
	1				4	5			8	
Empirical Females	5					5	6		8	
	18		2					7	8	
	4				4	5			8	
	20					5	6		8	
	30				4				8	9
	27				4	5			8	
	33				4		6	7		
	15				4	5		7		

Table (continued)

Sex K.A.M.	ID	Mini Scenarios and Identified Modality								
		1 R	2 N	3 E	4 N	5 E	6 R	7 N	8 E	9 R
Rational Males	47		2		4		6			
	29				4	5			8	
	26				4	5				9
	44	1				5			8	
	8				4	5				9
	22	1			4					9
	45			3		5			8	
	46	1					6		8	
Rational Females	43				4		6			9
	34					5	6		8	
	17				4		6	7		
	3					5	6		8	
	35		2		4		6			
	9				4	5			8	
	28					5	6	7		
	6	1	2		4					

AWARD PROBLEM

Sex K.A.M.	ID	Mini Scenarios and Identified Modality								
		1 N	2 R	3 R	4 E	5 R	6 E	7 N	8 E	9 N
Noetic Males	41	1				5	6			
	48		2		4					9
	23					5	6		8	
	31		2		4					9
	37				4		6			9
	14		2		4					9
	13		2		4					9
	42		2		4					9
Noetic Females	32					5	6	7		
	40							7	8	9
	36						6		8	9
	39		2		4		6			
	25						6	7	8	
	10						6	7	8	
	38		2				6	7		
	24				4		6			9
Empirical Males	7			3	4				8	
	2					5	6			9
	11	1					6		8	
	19	1					6	7		
	12				4		6	7		
	16						6	7	8	
	21	1					6		8	
	1		2		4					9
Empirical Females	5		2		4				8	
	18		2				6	7		
	4			3		5			8	
	20				4		6			9
	30				4				8	9
	27					5	6	7		
	33					5	6	7		
	15		2				6			9

Table (continued)

Sex	K.A.M.	ID	Mini Scenarios and Identified Modality								
			1 N	2 R	3 R	4 E	5 R	6 E	7 N	8 E	9 N
Rational	Males	47				4		6	7		
		29				4			7		9
		26					5		7		9
		44			3	4		6			
		8	1					6		8	
		22			3	4				8	
		45		2				6			9
		46	1					6	7		
Rational	Females	43					5	6	7		
		34	1						7	8	
		17		2				6			9
		3		2				6	7		
		35	1				5	6			
		9				4	5				9
		28				4		6	7		
		6	1			4			7		

APPENDIX J

Number of Noetic, Empirical, Rational Responses Selected by Each Problem Solver Solving Each Problem

Sex	K.A.M.	Problem Solver (ID)	Task N	Task E	Task R	Interview N	Interview E	Interview R	Award N	Award E	Award R
		41	1	1	1	1	1	1	1	1	1
		48	2	-	1	1	1	1	1	1	1
		23	1	2	-	1	2	-	-	2	1
M	Noetic	31	1	1	1	3	-	-	1	1	1
		37	3	-	-	3	-	-	1	2	-
		14	1	1	1	1	-	2	1	1	1
		13	1	1	1	2	-	1	1	1	1
		42	1	1	1	-	2	1	1	1	1
	Total		11	7	6	12	6	6	7	10	7
		32	2	1	-	2	1	-	1	1	1
		40	3	-	-	3	-	-	2	1	-
		36	1	1	1	1	-	2	1	2	-
F	Noetic	39	1	2	-	1	2	-	-	2	1
		25	3	-	-	1	1	1	1	2	-
		10	1	1	1	-	1	2	1	2	-
		38	1	-	2	-	2	1	1	1	1
		24	2	-	1	2	-	1	1	2	-
	Total		14	5	5	10	7	7	8	13	3
		7	1	1	1	1	-	2	-	2	1
		2	-	2	1	2	1	-	1	1	1
		11	-	2	1	1	-	2	1	2	-
M	Empirical	19	1	2	-	1	1	1	2	1	-
		12	1	1	1	1	2	-	1	2	-
		16	-	2	1	1	1	1	1	2	-
		21	2	-	1	-	1	2	1	2	-
		1	1	1	1	1	-	2	1	1	1
	Total		6	11	7	8	6	10	8	13	3
		5	1	1	1	-	2	1	-	2	1
		18	1	1	1	2	1	-	1	1	1
		4	1	1	1	1	2	-	-	1	2
F	Empirical	20	2	1	-	-	2	1	1	2	-
		30	1	2	-	1	1	1	1	2	-
		27	1	1	1	1	2	-	1	1	1
		33	1	1	1	2	-	1	1	1	1
		15	1	2	-	2	1	-	1	1	1
	Total		9	10	5	9	11	4	6	11	7

Table (continued)

Sex	K.A.M.	Problem Solver (ID)	Task N	Task E	Task R	Interview N	Interview E	Interview R	Award N	Award E	Award R
		47	1	2	-	2	-	1	1	2	-
		29	-	1	2	1	2	-	2	1	-
		26	1	1	1	1	1	1	2	-	1
M	Rational	44	-	2	1	-	2	1	-	2	1
		8	-	2	1	1	1	1	1	2	-
		22	2	1	-	1	-	2	-	2	1
		45	1	2	-	-	3	-	1	1	1
		46	-	2	1	-	1	2	2	1	-
	Total		5	13	6	6	10	8	9	11	4
		43	2	-	1	1	-	2	1	1	1
		34	1	-	2	-	2	1	2	1	-
		17	2	1	-	2	-	1	1	1	1
F	Rational	3	2	-	1	-	2	1	1	1	1
		35	1	-	2	2	-	1	1	1	1
		9	1	-	2	2	1	-	1	1	1
		28	-	1	2	1	1	1	1	2	-
		6	2	1	-	2	-	1	2	1	-
	Total		11	3	10	10	6	8	10	9	5

APPENDIX K

Protocol Summary Tables

Protocol Analysis for Noetic Males Solving the Task Problem

Problem Solver (ID):	41	48	23	31	37	14	13	42
Strategy	A	A	A	A	C.3	C.2	C.3	A
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1	1	1	1	1	1
Reviewed Highlights					1			
Planning Statement								1
Observation Statement				1	1			
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed					9	5	9	
# Appraised Positively					1			
# Appraised Negatively					1			
# Excluded					4	5	5	
# Included					2		2	
Added Criteria					1			
Restated Added Criteria					3			
Planning Statement						1		
Restated Task	1							
Observation Statement				1				
Step 3: Second Review of Mini Scenarios								
# of MS Considered	3	5	3	9	4	4	3	9
# Addressed		4	3	9	4	4		9
# Appraised Positively								3
# Excluded					1	1		2
# Included	3	3	3		3	3	3	
Added Criteria	1	1						1
Restated Added Criteria								1
Reviewed Highlights				1				
Planning Statement				1				
Restated Task				1				
Problem Solved	*	*	*		*	*	*	
Step 4: Third Review of Mini Scenarios								
# of MS Considered				8				4
# Addressed				2				4
# Appraised Positively				1				
# Included								2

(continued)

Problem Solver (ID):	41	48	23	31	37	14	13	42
Step 5: Fourth Review of Mini Scenarios								
# of MS Considered				8				2
# Addressed				8				2
# Appraised Positively				2				
# Appraised Negatively				3				
# Included								1
Planning Statement				1				
Problem Solved								*
Step 6: Fifth Review of Mini Scenarios								
# of MS Considered				3				
# Addressed				3				
# Included				3				
Problem Solved				*				

Protocol Analysis for Noetic Males
Solving the Interview Problem

Problem Solver (ID):	41	48	23	31	37	14	13	42
Strategy	B	A	A	B	C.2	A	C.3	2
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1	1	1		1	1
Read in Segments						1		
Observation Statement				1				
Reviewed Highlights						1		
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	9			7	9		9	2
# Appraised Positively								2
# Excluded					3		2	
# Included							1	
Added Criteria				1				
Reviewed Highlights				1				
Observation Statement						1		
Step 3: Second Review of Mini Scenarios								
# of MS Considered	7	9	3	4	9	3	6	7
# Addressed	3		3	4	9	3	6	7
# Appraised Positively					4		1	2
# Excluded					5		2	1
# Included	3		3			3	2	3
Added Criteria		1						1
Restated Added Criteria								1
Reviewed Highlights			1					
Restated Task				1		1		
Problem Solved	*		*			*	*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered		3		9	4			
# Addressed		3			4			
# Excluded					1			
# Included		3			3			
Reviewed Highlights				1				
Restated Task				1				
Planning Statement				2				
Observation Statement		1		3				
Problem Solved		*			*			

(continued)

Problem Solver (ID):	41	48	23	31	37	14	13	42
Step 5: Fourth Review of Mini Scenarios								
# of MS Considered				9				
# Addressed				9				
# Excluded				2				
Added Criteria				1				
Reviewed Highlights				1				
Planning Statement				1				
Observation Statement				2				
Step 6: Fifth Review of Mini Scenarios								
# of MS Considered				3				
# Addressed				3				
# Included				3				
Problem Solved				*				

Protocol Analysis for Noetic Males
Solving the Award Problem

Problem Solver (ID):	41	48	23	31	37	14	13	42
Strategy	A	A	A	A	B	B	C.3	C.2
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1	1		1	1	
Read in Segments					1			1
Observation Statement					1	2		
Reviewed Highlights					1			
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed					9	2	9	2
# Appraised Positively					6			1
# Excluded							1	1
# Included							1	
Added Criteria					4			
Restated Added Criteria					1			
Reviewed Highlights					5			1
Observation Statement				2				
Step 3: Second Review of Mini Scenarios								
# of MS Considered	3	3	3	6	7	6	6	6
# Addressed			3	6	7	6	6	
# Excluded					2	1		1
# Included	3	3	3		1	3		
Added Criteria	1	3		1		1		
Restated Added Criteria					1	3		3
Reviewed Highlights	1			1	2			
Observation Statement	1				1			
Problem Solved	*	*	*			*		
Step 4: Third Review of Mini Scenarios								
# of MS Considered				4	3		3	4
# Addressed				4				4
# Excluded							3	
# Included					3			3
Added Criteria					3			
Restated Added Criteria				1			3	1
Reviewed Highlights				1				
Observation Statement				2				
Problem Solved						*		*

(continued)

Problem Solver (ID):	41	48	23	31	37	14	13	42
Step 5: Fourth Review of Mini Scenarios								
# of MS Considered				5				
# Addressed				5				
# Excluded				1				
# Included				2				
Restated Added Criteria				1				
Reviewed Highlights				1				
Planning Statement				1				
Observation Statement				2				
Step 6: Fifth Review of Mini Scenarios								
# of MS Considered				4				
# Addressed				3				
# Excluded				1				
# Included				3				
Problem Solved				*				

Protocol Analysis for Noetic Females Solving the Task Problem

Problem Solver (ID):	32	40	36	39	25	10	38	24
Strategy	B	B	B	C.2	A	C.2	A	B
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1	1	1	1	1	1
Read in Segments					1	1	1	1
Restated Task						1		
Added Criteria			1					
Observation Statement	1							
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	9	9	6	9		3		3
# Appraised Positively	3	5		3				
# Appraised Negatively	3	3	2	2		1		
# Excluded				2		1		
Added Criteria					1			
Planning Statement			1					
Summary Statement								
Step 3: Second Review of Mini Scenarios								
# of MS Considered	8	5	5	9	4	3	8	5
# Addressed	3	5	3	3	4	3	8	5
# Appraised Positively	1	3	2					
# Appraised Negatively				3	1		5	2
# Excluded	1	2		2	3	3	3	3
# Included		3	3	1				
Planning Statement	1							
Restated Task	1							
Observation Statement								
		*	*		*	*	*	*
Problem Solved								
Step 4: Third Review of Mini Scenarios								
# of MS Considered	5			1				
# Addressed	1							
# Excluded	1			1				
# Included	3							
				*				
Problem Solved	*							

Protocol Analysis for Noetic Females
Solving the Interview Problem

Problem Solver (ID):	32	40	36	39	25	10	38	24
Strategy	B	C.2	A	B	A	C.2	A	A
Step 1: Reading the Main Scenario								
Read Main Scenario	1		1				1	1
Read in Segments		1		1	2	1		
Added Criteria		1						
Reviewed Highlights	1	1			1	1		
Observation Statement		1		1				
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	9	9		9		9		
# Appraised Positively		2				3		
# Appraised Negatively		2						
# Excluded		2				1		
Added Criteria	1					1		
Restated Added Criteria						1		
Reviewed Highlights	3	1	1			1		
Restated Task							1	1
Observation Statement			2					
Step 3: Second Review of Mini Scenarios								
# of MS Considered	9	4	9	4	3	3	5	3
# Addressed	9	4	9	4	3	3	5	3
# Appraised Positively	2		1					
# Appraised Negatively	3		1					
# Excluded			3		1		5	
# Included		2		3	2	3		3
Added Criteria							2	
Reviewed Highlights						1	1	
Planning Statement	1				1			
Problem Solved				*		*		*
Step 4: Third Review of Mini Scenarios								
# of MS Considered	4	2	5		8		4	
# Addressed	3		5		6		4	
# Appraised Negatively			1					
# Excluded			1		4		1	
# Included	3	1	3		3		3	
Problem Solved	*	*	*		*		*	

Protocol Analysis for Noetic Females
Solving the Award Problem

Problem Solver (ID):	32	40	36	39	25	10	38	24
Strategy	B	B	B	B	B	B	A	B
Step 1: Reading the Main Scenario								
Read Main Scenario	1		1		1		1	1
Read in Segments		1		1		1		
Added Criteria						3		
Reviewed Highlights		1			1	1		
Observation Statement	1		1	1	1	1		
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	9	9	2	8	2	9		2
# Appraised Positively	3	5		2		1		
# Appraised Negatively	1	3						
Added Criteria	1							
Restated Added Criteria	2					7		
Reviewed Highlights	2	4			1	1		
Observation Statement					1			
Step 3: Second Review of Mini Scenarios								
# of MS Considered	6	9	9	8	9	8	6	3
# Addressed	6	9	9	8	3	8	6	3
# Appraised Positively	1	2						
# Excluded	1	2	1	1	2		3	
# Included	3	2			3	2	3	3
Added Criteria				1			1	1
Restated Added Criteria				4		1	6	1
Reviewed Highlights		1	1	1				
Planning Statement					1			
Observation Statement						1		
Problem Solved	*				*		*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered		2	8	4		6		
# Addressed			8	4		5		
# Excluded			2			1		
# Included		1	3	3		1		
Reviewed Highlights				3				
Problem Solved		*	*	*		*		

Protocol Analysis for Empirical Males
Solving the Task Problem

Problem Solver (ID):	7	2	11	19	12	16	21	1
Strategy	C.2	B	B	B	B	B	A	C.2
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1		1		1	2
Read in Segments				1		1		
Added Criteria	1							
Planning Statement		1	1					
Restated Task	1							2
Observation Statement						1		3
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	9	9	9	9	9	6		9
# Appraised Positively	4	5			3			1
# Appraised Negatively		4			2			3
# Excluded	4							1
Added Criteria		1						
Restated Added Criteria		1						
Restated Task				1				
Observation Statement				7				
Step 3: Second Review of Mini Scenarios								
# of MS Considered	5	9	9	9	7	4	4	3
# Addressed	5	9	9	9	7		3	3
# Appraised Positively		3			2			
# Appraised Negatively		2						
# Excluded	2				1	1		
# Included	3			3	3	3	3	3
Added Criteria						1	1	
Reviewed Highlights					1			
Observation Statement				2				
Problem Solved	*			*	*	*	*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered		8	5					
# Addressed		8	5					
# Excluded			2					
# Included		2	3					
Added Criteria		2	2					
Restated Added Criteria		1	1					
Problem Solved			*					

(continued)

Problem Solver (ID):	7	2	11	19	12	16	21	1
Step 5: Fourth Review of Mini Scenarios								
# of MS Considered	1							
# Addressed	1							
# Included	1							
Problem Solved	*							

Protocol Analysis for Empirical Males
Solving the Interview Problem

Problem Solver (ID):	7	2	11	19	12	16	21	1
Strategy	C.2	B	B	B	B	C.2	A	C.2
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1		1		1	1
Read in Segments				1		1		
Observation Statement			1			1		3
Reviewed Highlights	1							
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	9	9	9	9	1	9		9
# Appraised Positively	2					3		2
# Appraised Negatively								2
# Excluded	2					2		2
Reviewed Highlights				3		1		
Observation Statement				10				
Restated Task		1						
Step 3: Second Review of Mini Scenarios								
# of MS Considered	7	9	9	9	5	4	3	8
# Addressed		9	9	9	5	4	3	8
# Appraised Positively	1	2			5			
# Appraised Negatively		1						3
# Excluded	3	3				1		
# Included	3					3	3	3
Added Criteria		1						
Reviewed Highlights		1	2	1				
Planning Statement			1					
Restates Task			2					
Observation Statement			3	12				
Problem Solved	*					*	*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered		4	9	8	5			
# Addressed		3	3	8	5			
# Positively Appraised			2					
# Excluded		1			2			
# Included		3		3				
Added Criteria				3	2			
Reviewed Highlights		1	3					
Observation Statement			2	8				
Problem Solved		*		*	*			

(Continued)

Problem Solver (ID):	7	2	11	19	12	16	21	1
Step 5: Fifth Review of Mini Scenarios								
# of MS Considered			8					
# Included			3					
Reviewed Highlights			1					
Problem Solved			*					

Protocol Analysis for Empirical Males
Solving the Award Problem

Problem Solver (ID):	7	2	11	19	12	16	21	1
Strategy	C.3	B	B	B	B	B	A	B
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1		1		1	1
Read in Segments				1		1	1	
Reviewed Highlights								1
Planning Statement	1							
Observation Statement		1			1	1		
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	9	9	9	9	9	9		9
# Appraised Positively	3	4				4		5
# Appraised Negatively		3	1					4
# Excluded	1							
Added Criteria	1	1						
Restated Added Criteria		3						
Reviewed Highlights	4	2	5	9	2			5
Observation Statement		1				1		
Step 3: Second Review of Mini Scenarios								
# of MS Considered	8	9	9	3	9	7	3	4
# Addressed	8	9	9	3	9		3	4
# Appraised Positively	3	3				1		
# Appraised Negatively	1							
# Excluded	2		1		4			
# Included		3	2	3	3	3	3	3
Added Criteria		1			1	1		
Restated Added Criteria		2						
Reviewed Highlights	3		1	2				
Planning Statement			1					
Problem Solved		*		*	*	*	*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered	3		3					
# Addressed	1		3					
# Included	3		1					
Problem Solved	*		*					

Protocol Analysis for Empirical Females
Solving the Task Problem

Problem Solver (ID):	5	18	4	20	30	27	33	15
Strategy	C.2	A	C.2	B	C.2	C.2	C.2	C.2
Step 1: Reading the Main Scenario								
Read Main Scenario	1				1	1	1	1
Read in Segments		1	1	1				
Reviewed Highlights						1		
Restated Task				1				1
Observation Statement	1			1		1		
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	5		9	7	5	9	8	9
# Appraised Positively			3			3	2	3
# Appraised Negatively	1		1				3	1
# Excluded	1		3		4	3	3	2
Reviewed Highlights			2					
Observation Statement				1	1			
Step 3: Second Review of Mini Scenarios								
# of MS Considered	9	8	5	6	9	4	8	4
# Addressed	9	8	5	6	5	4	8	4
# Appraised Positively	2		3	3				
# Appraised Negatively	1						1	
# Excluded	4	5	1	2	1	1	4	1
# Included		3	3	1	3	3	3	3
Added Criteria				1				
Planning Statement		1			1			
Problem Solved		*	*		*	*	*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered	5			3				
# Addressed	4			3				
# Included	3			3				
Added Criteria				1				
Problem Solved	*			*				

Protocol Analysis for Empirical Females
Solving the Interview Problem

Problem Solver (ID):	5	18	4	20	30	27	33	15
Strategy	B	C.2	C.2	C.2	C.2	C.2	C.2	C.2
Step 1: Reading the Main Scenario								
Read Main Scenario		1		1	1	1	2	1
Read in Segments	1		1					
Reviewed Highlights				1		1	1	
Planning Statement	1							
Observation Statement	1			1				1
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	9	9	9	9	2	9	9	9
# Appraised Positively	5		2	1		4		2
# Appraised Negatively							2	1
# Excluded		1	4	3	1	3	1	1
# Included						1		
Reviewed Highlights			5	8		1		
Observation Statement			1	1		1	3	
Step 3: Second Review of Mini Scenarios								
# of MS Considered	5	8	6	9	9	3	9	6
# Addressed	5	8	6	9	9	3	9	6
# Appraised Positively	3	1	2	1			2	
# Appraised Negatively		1						
# Excluded			2		2		3	2
# Included			3			2		3
Added Criteria	1							2
Restated Added Criteria								1
Reviewed Highlights	2							
Observation Statement	1	1						1
Problem Solved			*			*		*
Step 4: Third Review of Mini Scenarios								
# of MS Considered	9	4		6	6		5	
# Addressed	9	4		6	6		5	
# Excluded	6				2		1	
# Included	3	3		1				
Added Criteria				1				
Restated Added Criteria				1				
Reviewed Highlights	1			1				
Problem Solved	*	*						

(continued)

Problem Solver (ID):	5	18	4	20	30	27	33	15
Step 5: Fourth Review of Mini Scenarios								
# of MS Considered				3	6		4	
# Addressed				3	6		4	
# Excluded					3			
# Included				3	3		3	
Added Criteria					1			
Restated Added Criteria					1			
Reviewed Highlights				1				
Problem Solved				*	*		*	

Protocol Analysis for Empirical Females
Solving the Award Problem

Problem Solver (ID):	5	18	4	20	30	27	33	15
Strategy	B	B	C.2	C.2	B	C.2	B	B
Step 1: Reading the Main Scenario								
Read Main Scenario		1			1	1	1	
Read in Segments	1		1	1				1
Reviewed Highlights					1		1	
Observation Statement		1						
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed	9	9	9	9	9	9	9	8
# Appraised Positively	4		3			2	5	2
# Appraised Negatively	1						2	1
# Excluded			3	2		1		
# Included						2		
Added Criteria				1		1		
Restated Added Criteria						1		
Reviewed Highlights	6		7	11	1		2	
Observation Statement					1			
Step 3: Second Review of Mini Scenarios								
# of MS Considered	9	7	7	9	8	3	9	7
# Addressed	8	7	7	9	8		9	7
# Appraised Positively	1		3					1
# Appraised Negatively			1					
# Excluded	5	3	1	6	1		3	4
# Included	3		3	3		3		2
Added Criteria				1				
Restated Added Criteria				6				
Reviewed Highlights				1	1			1
Observation Statement	1			3	1			1
Problem Solved	*		*	*		*		
Step 4: Third Review of Mini Scenarios								
# of MS Considered		6			9		6	4
# Addressed		6			9		6	2
# Excluded		3					3	
# Included							3	3
Added Criteria					1			
Reviewed Highlights		2						
Observation Statement					1		2	2
Problem Solved							*	*

(continued)

Problem Solver (ID):	5	18	4	20	30	27	33	15
Step 5: Fourth Review of Mini Scenarios								
# of MS Considered		5			9			
# Addressed		3			9			
# Excluded					6			
# Included		3			3			
Reviewed Highlights					1			
Observation Statement					3			
Problem Solved		*			*			

Protocol Analysis for Rational Males
Solving the Task Problem

Problem Solver (ID):	47	29	26	44	8	22	45	46
Strategy	A	A	B	A	B	C.3	C.3	A
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1	1	1		1	2
Read in Segments						1		
Restated Task			1					
Observation Statement				1				
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed			9		1	9	9	
# Appraised Positively						1		
# Appraised Negatively			1			1		
# Excluded						3	4	
# Included						1	2	
Restated Task				1				
Observation Statement							3	
Step 3: Second Review of Mini Scenarios								
# of MS Considered	3	8	9	8	9	3	3	4
# Addressed	3	7	9	8	9	3	1	4
# Appraised Positively			4					
# Appraised Negatively			1					
# Excluded				4				
# Included	3	1	3	3		3	3	3
Added Criteria	1				2			
Reviewed Highlights		1	1			1		
Planning Statement			1		1			
Problem Solved	*			*		*	*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered		5	5		9			
# Addressed		5	5		9			
# Included		3	3		3			
Added Criteria			1					
Problem Solved		*	*		*			

Protocol Analysis for Rational Males
Solving the Interview Problem

Problem Solver (ID):	47	29	26	44	8	22	45	46
Strategy	A	A	B	C.2	B	A	C.3	B
Step 1: Reading the Main Scenario								
Read Main Scenario	1		1		1	1	1	1
Read in Segments		1		1				
Restated Task							1	
Observation Statement			1		1	1		
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed			9	9	2		9	9
# Appraised Positively							2	1
# Excluded				1			2	
Reviewed Highlights			6		1			1
Restated Task				1	1			
Observation Statement					1			
Step 3: Second Review of Mini Scenarios								
# of MS Considered	9	9	9	3	9	9	3	9
# Addressed	9	9	9	3	4	9		9
# Appraised Positively					1			
# Appraised Negatively	4		1			1		
# Excluded	2		2			2		
# Included	3		3	3		3	3	2
Added Criteria					1			2
Reviewed Highlights	1					2		
Planning Statement		1	1			1		
Observation Statement		1						1
Problem Solved	*		*	*		*	*	
Step 4: Third Review of Mini Scenarios								
# of MS Considered		4			8			5
# Addressed					8			5
# Excluded								2
# Included		3			3			3
Reviewed Highlights					1			
Observation Statement		1			1			
Problem Solved		*			*			*

Protocol Analysis for Rational Males
Solving the Award Problem

Problem Solver (ID):	47	29	26	44	8	22	45	46
Strategy	A	A	B	B	B	C.2	C.1	B
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1			1			1
Read in Segments			1	1		1	1	
Reviewed Highlights			1					
Observation Statement			1					
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed		1	9	2	2	9	9	9
# Appraised Positively			2	1	1	3	4	4
# Appraised Negatively			1			2		1
# Excluded						2		
# Included							1	
Reviewed Highlights			6			3	1	3
Planning Statement							2	
Observation Statement							6	
Step 3: Second Review of Mini Scenarios								
# of MS Considered	9	9	9	3	6	8	4	4
# Addressed	9	9	9	3	6	8	4	4
# Appraised Positively			3			2		
# Excluded	4		3		1			
# Included	3		3	3	3	3	3	3
Reviewed Highlights		1						
Planning Statement	1		1					
Observation Statement	4						1	
Problem Solved	*		*	*	*	*	*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered		6						
# Addressed		6						
# Included		3						
Observation Statement		1						
Problem Solved		*						

Protocol Analysis for Rational Females
Solving the Task Problem

Problem Solver (ID):	43	34	17	3	9	35	28	6
Strategy	A	C.3	A	C.2	C.2	B	B	A
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1	2	1			1
Read in Segments						1	1	
Planning Statement								1
Restated Task				1		1	1	1
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed		6		9	9	3	9	
# Appraised Positively		1			1	2		
# Appraised Negatively				1	1			
# Excluded		1		2	2			
# Included		1						
Reviewed Highlights				1				
Restated Task			1					
Observation Statement					1			
Step 3: Second Review of Mini Scenarios								
# of MS Considered	8	5	9	5	5	5	5	9
# Addressed	8	5	9	5	5	5	5	9
# Appraised Positively	3			4				
# Appraised Negatively								
# Excluded	2	1	4	1	1	1		2
# Included	1	3		3	3	3	3	3
Added Criteria	1		1					
Reviewed Highlights						1		
Planning Statement			1					
Observation Statement			1					
Problem Solved		*		*	*	*	*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered	5		4					
# Addressed	5		4					
# Excluded	1							
# Included	3		2					
Problem Solved	*		*					

(continued)

Problem Solver (ID):	43	34	17	3	9	35	28	6
Step 5: Fifth Review of Mini Scenarios								
# of MS Considered		7						
# Addressed		7						
# Excluded		2						
# Included		3						
Problem Solved		*						

Protocol Analysis for Rational Females
Solving the Interview Problem

Problem Solver (ID):	43	34	17	3	9	35	28	6
Strategy	A	C.2	B	B	B	B	B	A
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1	1				1
Read in Segments					1	1	1	
Reviewed Highlights			1		1	1		
Planning Statement				1				1
Restated Task					1			1
Observation Statement			2				1	1
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed		1	9	9	9	7	8	
# Appraised Positively		1	3	1	3	1		
# Appraised Negatively			2	3				
# Excluded					1			
Added Criteria			2					
Restated Added Criteria								
Reviewed Highlights				3	1	1		
Planning Statement				1				
Observation Statement		1		1				
Step 3: Second Review of Mini Scenarios								
# of MS Considered	9	9	3	9	6	6	7	9
# Addressed	9	9		9	6	6	7	9
# Appraised Positively	2	1		2		2		4
# Appraised Negatively				3				1
# Excluded	6	3		3	2	1	1	1
# Included	2		3		3	3	3	
Added Criteria	2	1		2				
Restated Added Criteria				1				
Reviewed Highlights	1			2		2		
Planning Statement		1		2				1
Observation Statement	1	1		3				1
Problem Solved			*		*	*	*	

(continued)

Problem Solver (ID):	43	34	17	3	9	35	28	6
Step 4: Third Review of Mini Scenarios								
# of MS Considered	6	5		8				3
# Addressed	6	5		8				3
# Positively Appraised				4				
# Excluded	2	2		2				
# Included	3	3						3
Reviews Highlights		1		2				
Planning Statement				1				
Observation Statement		2						
Problem Solved	*	*						*
Step 5: Fourth Review of Mini Scenarios								
# of MS Considered				8				
# Addressed				8				
# Excluded				2				
# Included				3				
Planning Statement				1				
Problem Solved				*				

Protocol Analysis for Rational Females
Solving the Award Problem

Problem Solver (ID):	43	34	17	3	9	35	28	6
Strategy	A	B	C.2	B	C.2	B	B	A
Step 1: Reading the Main Scenario								
Read Main Scenario	1	1	1	1				1
Read in Segments					1	1	1	
Reviewed Highlights						1		
Planning Statement								1
Observation Statement						1		1
Step 2: First Review of Mini Scenarios (abbreviated MS)								
# of MS Considered	9	9	9	9	9	9	9	9
# Addressed		9	9	9	9	8	9	
# Appraised Positively		3	3		5	2	1	
# Appraised Negatively		1						
# Excluded			2		2			
Added Criteria			2		1			
Restated Added Criteria					3			
Reviewed Highlights		6	4	4		4	7	
Observation Statement				1				
Step 3: Second Review of Mini Scenarios								
# of MS Considered	9	5	3	7	6	5	4	9
# Addressed	9	5	3	7	6	5	4	9
# Appraised Positively				2				
# Excluded	4			2	1	2		
# Included	3	3	3	2	3	3	3	3
Added Criteria				1				1
Reviewed Highlights	4			3			1	
Planning Statement					1			
Observation Statement				2				
Problem Solved	*	*	*		*	*	*	*
Step 4: Third Review of Mini Scenarios								
# of MS Considered				6				
# Addressed				6				
# Included				3				
Reviewed Highlights				1				
Problem Solved				*				