AN INVESTIGATION OF THE RELATIONSHIPS BETWEEN THE FOUR TYPOLOGICAL DIMENSIONS OF THE MYERS-BRIGGS TYPE INDICATOR AND PROBLEM-SOLVING SKILL LEVEL IN MATHEMATICS AT THE COMMUNITY COLLEGE

by

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CHAPTER ONE

Introduction

Poor student performance in mathematics on national achievement tests has led to increased demand for the development of a stable and useful body of knowledge on the variables contributing to the development of mathematical skills in students. In September of 1979, the National Assessment of Educational Progress Forum reported that while computational skills were maintained at a satisfactory level during the period from 1973 to 1979, the ability to solve problems had declined (Piemonte, 1981, pp. 18-200). Then, recognizing the ability to apply mathematics to solve problems as a fundamental skill, The National Council of Teachers of Mathematics (NCTM) announced its Recommendations for School Mathematics for the 1980s at the 1980 National Conference. The first recommendation stated, "Problem-solving must be the focus of school mathematics in the 1980s" (National Council of Teachers of Mathematics, 1980). Again, in 1986, the NCTM called for research on the affective variables involved in the teaching of problem-solving (Kilpatrick, ed., 1986, p. 318). Since then, and amid media reports of the lack of mathematical literacy among American students, mathematical association committees have dissected virtually every aspect of the mathematics curriculum. A consistent finding of the abundant national assessments of mathematical competency is that most students are still deficient in problem-solving skills (Kilpatrick, 1988, p. 274; Wechsler, 1989, pp. 24-25).

Indeed, researchers have begun to identify the cognitive structure of problem-solving (Mayer, 1980; 1981a, pp. 1-3) and cognitive psychologists have played a prominent role (Brainerd, 1982; Lester, 1982, pp. 55-56; Ginsburg, 1983; Lesh and Landau, 1983). Kilpatrick (1969) has described, in detail, the techniques that heretofore had been used by psychologists to study problem-solving abilities. At that time, mathematical problems rarely had been used in problem-solving research. Since then, researchers have begun to examine problem-solving abilities using mathematical examples. In the 1970s, much of the research in this area involved the collection of problem-solving protocols using the interview process. However, Lester and Garofalo have charged that while educators have greatly increased their knowledge of methods for fostering the development of problem-solving skills, "the research on the whole has been rather unsystematic and has lacked clarity of purpose and focus" (1982, p. ix). More recently, this sentiment has been repeated by Kilpatrick (1988) and Trismen (1988).

Yet, while the cognitive aspects of problem-solving have been researched, the human aspect has not been explored adequately (Piemonte, 1981, pp. 19-20; Briars, 1982, pp. 39-50; Kilpatrick, 1988; Trismen, 1988, pp. 338-344). In July, 1988, the NCTM presented an agenda for new research which suggested that problem-solving techniques involve more than mathematical procedures and are developed in a social setting among all of the variables implied by that setting (Kilpatrick, 1988, pp. 338-344; Silver, 1988, pp. 340-343). In this regard, charges have been made that the lack of the development of mathematical and problem-solving skills lies not with the content presented in mathematics courses, but with the teaching strategies used (Bloom et al., 1971; Reissman, 1976; Keefe, 1979; It Isn't the Math, It's the Teachers, March, 1989, p. 15A). Thus, student difficulties in the learning process may stem from a mismatch between instructional strategies and their problem-solving style. This line of reasoning has led to the emergence of the examination of problem-solving style as a key element in the effort to make learning and instruction more responsive to the needs of individual students. Along these lines, the tendency to apply a single approach to all students has been challenged (Reissman, 1976; Keefe, 1979; Kilpatrick, 1988; Silver, 1988). To this end, research is needed to clarify and identify personal preferences and attitudes affecting learning with respect to problem-solving skills in some students and the inhibition of this development in others.

In this respect, the community college student has become a major focus. Not only do these institutions serve as transfer or feeder institutions for four-year colleges, they also provide vocational course offerings. Nationwide, the community college strives to accommodate and educate over half of all undergraduates (Monroe, 1977, p. 1). Community college students arrive with diverse ethnic, socioeconomic, and academic backgrounds, as well as learning styles. Previously denied access to higher learning because of academic deficiencies, these students have been given an opportunity to develop skills necessary to be successful in higher education. The community college instructor must meet the needs of this heterogeneous group of students.

Statement of the Problem

A search of the literature revealed that research efforts have concentrated on the cognitive aspects of problem-solving. Similarly, demographic variables have been studied extensively in relation to success in mathematics (Aiken, 1976; Gustin, 1987). Much of the research in the affective domain has centered around math anxiety (Astin, 1975; Aiken, 1976; Stipek and Weiz, 1976; Adams, 1986; Hinkle, 1986) and student attitudes toward mathematics (Bassarear, 1987; Calhoun, 1987; Landerman, 1987). Affective variables, such as attitudes and motivational patterns, which significantly influence behavior, have not been studied extensively in relation to mathematical problem-solving (Kilpatrick, 1986; Trismen, 1988). The need for this additional research with regard to mathematics skill development has been indicated by Kantowski (1977; 1980) and Kilpatrick (1988).

During investigation of the interaction of conceptual knowledge and heuristic components in problem-solving situations, students were found to exhibit preferences for different styles of approach to problem-solving. For example, when confronted with a problem-solving task, one student may prefer to discuss the task and possible tactics with a peer, while another may prefer to work alone. Initial perceptions of the problem-solving task also affect the approach. Thus, the principles on which individuals base their reactions to the problem-solving task also impact upon their ability to problem-solve successfully. These styles of approach may be reflections of learning style.

Not everyone learns in the same way nor uses the same techniques to combine conceptual knowledge and the heuristic components of problem-solving (Lester, 1975; Meyer, 1978; Webb, 1979; Kulm and Days, 1979; Kantowski, 1980). Similarly, evidence indicates that people experience situations differently. These differences impact upon achievement in mathematics which centers around techniques which require students to decide how to use the knowledge already in their schema in conjunction with new information to create a solution. Thus, students must learn how to perceive the problem task accurately. They must use observational skills and be able to focus on the facts and details of the environment which are relevant to the problem-solving task. In addition, they must be able to fit past experiences together into new patterns, often using their imagination to explore new possibilities and to develop new approaches. This process requires decision-making skills as well as the ability to be objective and analytical. The final step, not to be taken lightly, involves consideration of the reasonableness of a solution.

In assessing student ability in problem-solving, Meyer (1978, pp. 1-2) reported that over half of the twelfth graders in California public schools were unable to solve simple word problems and that, nationally, only 29 percent were able to solve similar problems. The results of the 1988 National Assessment of Educational Progress survey indicated that for most students, mathematics classes were structured so that they watched the teacher work problems on the board and then worked additional problems provided by the teacher or in a worktext in isolation. This survey included an assessment of student beliefs and attitudes about mathematics, suggesting that too many students view mathematics as a memorization activity and strive to mimic the teacher (Brown, Carpenter, Kouba, Lindquist, Silver and Swafford, 1988).

The State of New Jersey has conducted a statewide assessment of student achievement in basic skills. In New Jersey, all entering college students must take the New Jersey College Basic Skills Placement Test, a test which is used to evaluate reading, writing, computational and algebraic reasoning skills. Based on a computational score and an algebraic score, students are placed in mathematics courses, classified according to three levels: developmental, prealgebra, and college level. Statewide, in fall, 1985, only 18.9 percent of the entering community college student cohort in New Jersey demonstrated proficiency in elementary algebra (Results of the New Jersey College Basic Skills Placement Test, March, 1986, pp. 6-8). Yet, only five percent reported one year or less of high school mathematics. Sadly, these results were consistent with those reported for previous years (Results of the New Jersey College Basic Skills Placement Test, March, 1986, p. 9; March, 1988, pp. 11). Atlantic Community College, Atlantic County, New Jersey reported that 1,343 incoming students were tested for the 1985 calendar year. Of those tested, 693 (51.6 percent) failed to pass the computational portion of the test, 475 (35.4 percent) failed to pass the elementary algebra portion, and only 175 (13.0 percent) achieved a score which permitted them to enter college level courses.

The poor performance of these entering students underscores the need for a better understanding of the factors bearing upon weak mathematical skills. Furthermore, there is a need for the development of instructional strategies which would capitalize on student strengths and preferences as well as strengthen their weaker skills. Mathematics educators have begun to recognize that traditional teaching practices in mathematics may, in fact, work to the disadvantage of certain types of learners.

Type Theory as described by Jung (1923) has provided the theoretical base for one system for identifying attitudes and motivational patterns in people (Lawrence, 1982, p. 24). According to this theory, individuals have preferences for processing information and interacting with others. Myers (1962) developed the Myers-Briggs Type Indicator (MBTI) to operationalize Jung's theory. Using the MBTI, qualitative differences in people are described in terms of type. Thus, people of different types have "a different 'mix' of abilities, different needs, interests and motivations, and different degrees of success in school" (Myers, 1980, p. 63). Furthermore, Peavy (1963) found that student scores on the MBTI were predictors of mathematics achievement.

In type theory it is assumed that if people experience things differently, their attitudes, assumptions, and actions will vary. Whether or not one is aware of it, each individual operates with a particular set of attitudes, assumptions, and actions called type. However, typology is not to be mistaken for psychology. Typology delineates: it does not diagnose, nor does it attempt to assess or evaluate personalities. Instead, it offers a detailed description of certain tendencies and potentialities, and certain orientations to time and space. Each type is characterized by a basic perceptual set affecting first, understanding and second, dealings with reality. This perceptual set influences a student's interaction or learning style in the classroom.

Learning style reflects a person's preferred approach to the components of the problem-solving task: information processing, idea formation, and decision-making (McCaulley and Natter, 1978; Lawrence, 1984). Morgan (1977) and McCaulley and Natter (1974) have explored extensively the relationship of type theory to teaching strategies and student learning styles. Specifically, two of the four MBTI scales, the Introversion (I)-Extraversion (E) and the Sensing (S)-Intuition (N) scales, interact to form a useful typology of learning styles (Lawrence, 1984; Davis, 1985). Learning style preference has been shown to have a definite impact on academic success (Witkin, Moore et al., 1977; Thomason, 1983; Hedlund, 1985; Emley, 1986; Hendrickson, 1986; Thompson, 1987; Olson, 1988; Neral, 1989). Using the MBTI as a learning style construct may prove useful in providing insight into the attitudinal and motivational patterns influencing successful problem-solving.

Purpose of the Investigation

The purpose of this investigation was to examine the degree to which different learning style preferences, as measured on the MBTI, relate to problem-solving skill level in mathematics among community college students. If a relationship exists, recommendations for educational strategies and support mechanisms based on these relationships could be made.

To achieve this purpose, the investigation was conducted in three stages. First, a synthesis of the literature was completed on the factors contributing to problem-solving skills and strategies for learning and the use of the MBTI as a construct for identifying student preferences for learning strategies. Second, the degree of problem-solving skill development was identified by determining mathematics skill level and score on a test of reasoning skills. The literature and personal observation led to two specific ideas:

1. Do students on the developmental level prefer working with concrete examples before examination of the conceptual principles underlying the problem-solving task?
2. Do students in college level courses prefer conceptualization of the task before developing

the solution?

Research questions and hypotheses were developed to direct the investigation based on those questions. These questions were tested empirically. Third, based on the findings from the first two stages, recommendations were made concerning teaching strategies which could be incorporated into the mathematics classroom and future research involving the use of the MBTI in identifying factors impacting upon the development of problem-solving skills. Secondly, as a result of identified relationships and learning style research based on the MBTI, recommendations were made.

Significance of the Study

Educators across the nation have reported that students lack motivation for school tasks (Lawrence, 1984, p. 24). Currently, there is widespread concern over the lack of development of mathematical skills and problem-solving abilities in students. Clearly, there is a need to identify instructional strategies which will improve students' learning of mathematics (Meyer, 1981b, p. 1; Lawrence, 1984, pp. 57-62). Contributions to the literature which will increase our knowledge of the variables influencing problem-solving abilities can aid educators. Moreover, the nation's economic recovery depends upon the ability to compete with new technology in the world market and problem-solving abilities are essential and fundamental to the development of the needed technological advancements (Johnson, 1989).

The relationship of type theory to problem-solving abilities has had direct implications for instruction (Jung, 1971; Myers, 1980; Lawrence, 1982). It has been suggested that motivation can be broken down into four components: natural interests, learning styles, values and commitments, and work habits (Lawrence, 1982, p. 24). These four components as determined by the Myers-Briggs Type Indicator (Myers, 1976) reflect the four dimensions of type theory described by Jung.

Further, Morgan (1977) has developed and verified classroom instructional strategies corresponding to the four defined dimensions of the MBTI. Thus, type theory has provided insight into how teachers can match teaching strategies to students. Traditional instruction has been shown to give an advantage to some types while handicapping others. By providing an environment which diminishes these handicaps and by presenting problem-solving in a way that is congruent with motivational patterns, learning can be enhanced (Morgan, 1977). For example, an individual of one type may prefer the presentation of a conceptual base before the presentation of applications. This order of presentation may be alien to another type of individual who prefers to examine applications before considering concept development. The association of type to problem-solving ability may provide an understanding of how the student processes information when confronted with problem-solving tasks and how the student views the relationships among the variables of the problem.

If MBTI variables are found to have predictive value at the problem-solving skill level, this information might be useful for prescriptive purposes. Hence, it would be possible to develop educational strategies which would take into account human factors and lead to improvement of the learning of mathematics and problem-solving in educational settings. Furthermore, if there is a relationship between student learning style, as assessed by the MBTI, and mathematical achievement level, then appropriate support mechanisms could be developed to enable the student to bridge the gap between developmental or remedial mathematics coursework and college level coursework.

Exploratory research on the relationship between the dimensions of type theory and the levels of reasoning skills and conceptual mastery of mathematical concepts will add to the body of knowledge on the problem-solving process. If such a relationship is shown, hypotheses for future inquiries on the development of effective teaching strategies as well as academic counseling may be suggested.

Research Questions

To respond to the problem statement, three research questions were addressed:

1. Is there a relationship between the dimensions of type as measured on the MBTI and mathematical achievement level as indicated by placement in one of the three mathematics course levels among community college students?
2. Is there a relationship between the dimensions of type as measured on the MBTI and course level as indicated by placement criteria among community college students?
3. Is there a relationship between the dimensions of type as measured on the MBTI and problem-solving ability as indicated by total score on the New Jersey Test of Reasoning Skills?

The first research question assumed that problem-solving ability relates to mathematical achievement level. The second research question examined a breakdown of the levels by course. The courses sampled in the study were hierarchical according to a prerequisite system. The third research question used a tool to provide a measure of problem-solving ability. The tool, the New Jersey Test of Reasoning Skills, had been shown to correlate highly with the mathematical placement process used (Lipman, 1985). Before the third question was explored, the relationship between skill level and the results of the reasoning skills test was verified for the sample. Each question, in turn, was a cross validation of the others. Thus, through investigation of these three broad research questions, insight was obtained into the relationship of preference type to problem-solving skill level.

Hypotheses

In addition, three hypotheses related to the research questions were tested and four more focused hypotheses describing the directional relationship of achievement level to the dimensions of type were addressed:

1. The indices of the MBTI interact significantly to predict achievemnt level.
2. The indices of the MBTI interact significantly to predict course level.
3. The indices of the MBTI interact significantly to predict problem-solving ability.
4. Students in developmental level courses demonstrate a stronger preference toward the introversion dimension of the extraversion/introversion index than students in the higher level courses.
5. Students in developmental level courses demonstrate a stronger sensing preference on the

sensing/intuition index than students in higher level courses.

6. Students in developmental level courses demonstrate a stronger thinking preference on the thinking/feeling index than students in higher level courses.

7. Students in developmental level courses demonstrate a stronger preference in the judgment direction of the judgment/perception index than students in the higher level courses.

The hypotheses were based upon the researcher's empirical observations during her 20 years experience in teaching college students and the study of MBTI type preferences. Some of the behaviors observed frequently in lower level classes, but not upper level classes have included:

- Students are reluctant to ask questions or work with peers in small groups.
- Students ask for concrete, everyday examples.
- Students ask to be given instructions for assignments in minute detail.
- Students ask for a step-by-step process or rule to solve problems.
- Students want the teacher to show them every problem.
- Students desire continual feedback on progress and need to know exactly how they have been and will be graded throughout every phase of the class and want to know "all the rules" for the class.

Definitions of Terms

Mathematics Achievement Level. Mathematics achievement at a point in time is defined according to the three placement levels as indicated on the New Jersey College Basic Skills Placement Test (NJCBSPT) and/or achievement of a grade of "C" or better in the college level mathematics course taken as a prerequisite to their current course level.

Problem-Solving Ability. Problem-solving ability is defined in terms of a student's score on the New Jersey Test of Reasoning Skills.

Problem-Solving Style. Problem-solving style is described in terms of the eight dimensions of type as indicated on the Myers-Briggs Type Indicator.

Extraversion. Extraversion (E) is the tendency to relate more easily to the outer world of people and things than to the inner world of ideas.

Introversion. Introversion (I) is the tendency to relate more easily to the inner world of ideas than to the outer world of people and things.

Sensing. Sensing (S) is the preference for working with known facts rather than looking for possibilities and relationships.

Intuition. Intuition (N) is the preference for looking for possibilities and relationships.

Thinking. Thinking is the tendency to base judgments more on impersonal analysis and logic as opposed to personal values.

Feeling. Feeling is the tendency to base judgments on personal values rather than analysis and logic.

Judging Attitude. The judging attitude is the preference for a planned, decided, orderly way of life rather than a flexible, spontaneous way.

Perceptive Attitude. The perceptive attitude is the preference for a flexible, spontaneous way of life over a planned, decided orderly one.

Type. Type is defined in terms of the 16 categories indicated on the Myers-Briggs Type Indicator.

Assumptions

The following assumptions were essential to this study:

1. Type as described by Jung can be measured and the Myers-Briggs Type Indicator provides a reasonable construct of these dimensions.

2. Paper and pencil instruments such as the New Jersey College Basic Skills Placement Test and the New Jersey Test of Reasoning Skills provide a viable measure of problem-solving ability.

3. The dimensions of type as measured on the MBTI can be associated with learning styles as indicated by Morgan (1977).

4. Problem-solving style is a reflection of learning style.

Limitations of the Study

The following comprise the limitations of this study:

1. The population is limited to those students enrolled in all levels of mathematics courses offered during the fall, 1986 semester at Atlantic Community College.

2. The generalization of the data is limited to the extent that students involved in this study are representative of other community college students.

3. The range of age differences in community college students may affect problem-solving ability. Older students may have developed a broader range of problem-solving strategies and mathematical skills.

4. Differences in conceptual schemas may account for differences in problem-solving abilities.

5. The measurement of problem-solving style and problem-solving skill level are limited by the acceptance of the limitations of the MBTI, the placement test and the reasoning skills test. These limitations consist of:

. The validity and reliability of these measures.

. The degree to which the respondents completed the pencil and paper assessments honestly and completely.

Overview of the Dissertation

Chapter One provided an overview of the statement of the problem. This overview pointed out that mathematics achievement and problem-solving ability, in particular, have not been maintained by students at a satisfactory level. Previous efforts to study problem-solving abilities were described along with the need for more information on the variables contributing to the development of problem-solving skills. Research questions and hypotheses based upon investigating possible relationships between problem-solving, learning styles and achievement level were posed. The chapter concluded with a definition of key terms, assumptions and limitations of the investigation.

Chapter Two provides a review of the literature. Included in this review is research supporting the theory that students learn in different ways. The theory underlying the MBTI is described as is the research which shows the applied interpretation and use of the MBTI as it relates to learning styles and achievement.

Chapter Three begins with a restatement of the purpose and rationale as well as the research questions and hypotheses. This is followed by an explanation of the research design, descriptions of the instrumentation, the population and sampling procedure, data collection techniques, and an overview of the methods used in the analysis.

The findings of the investigation are presented in Chapter Four. The outcomes of the investigation with respect to the research questions and hypotheses are presented along with characteristics of the sample with regard to variables measured.

Finally, a summary of the research findings, implications for instruction, and recommendations for further research based upon the results of this study will be presented in Chapter Five.

A bibliography and appendices also are included in the study.

Chapter Two

Review of Related Literature

In a effort to explore adequately the factors influencing the development of problem-solving skills, the literature review is eclectic, drawing on theories and research related to problem-solving, learning and thinking tools, and the theories relating to learning style preferences. Chapter Two is organized as follows. First, a synopsis of the related literature describing the characteristics of problem-solving skills is presented. Second, aspects of learning theory as applied to problem-solving are discussed. Third, the theoretical base for the typology theory underlying the Myers-Briggs Type Indicator is explained. Fourth, the typology theory of Myers and Briggs along with related research are reviewed.

Problem-Solving Research

A number of educators and non-educators have contributed to the current body of knowledge on the problem-solving process. Research in this area has origins in different fields, rather than one common area. A number of cognitive psychologists have focused on the types of knowledge relevant to mathematical problem-solving (Mayer, 1980, 1981a). The stages of problem-solving have been determined (Polya, 1968). The thought process has been studied by Williams

(1987) and Thompson (1987) who found that when diagrams are included in instruction, success increases. Linguistic and structural variables in problem-solving have been examined (Loftus and Suppes, 1972; Heller and Greeno, 1978; Riley and Greeno, 1978; Clement, Lockhead, and Soloway, 1979, 1980; Greeno, 1980). Stiff (1989) studied the effects of different teaching strategies on the learning process and has recommended more indepth examination of the relationship of teaching/learning strategies to successful problem-solving. Smith and Holliday (1987) found that students in high, medium, and low groups, according to problem-solving skill, differed significantly on six learning style factors. Also examined were the relationships between problem-solving style, nonroutine problems, and transfer (Kantowski, 1977).

As the problem-solving process has been studied, the definition of problem-solving has been expanded to include not only the solving of traditional verbal or word problems, but other types of problems as well. A major type considered has been the nonroutine problem. This type of problem has been called properly the key to understanding the problem-solving process. A nonroutine problem exists if the person attempting to solve the problem has no algorithm as a part of his or her current conceptual knowledge base upon which to guarantee a solution. Thus, it is a question which cannot be resolved with the knowledge or skills immediately available to the problem-solver (Kantowski, 1974; Lester, 1975; Schoenfeld, 1979, 1980). This type of problem-solving has been shown to be most important in helping students to transfer methods of problem-solving to other situations and in helping them to grasp the structure of mathematics and to apply it appropriately to other situations (Meyer, 1978; Webb, 1979).

Much of the early research focused on three stages of problem-solving: understanding the problem, planning a solution and computational skills. These constitute the first three stages of problem-solving described by Polya (1973). Polya's fourth stage involved looking back or testing the reasonableness of the solution. Many of the studies seemed to indicate that a major reason for failure by students is connected to the inability to understand the problem or task (Gurova, 1969; Kalmykova, 1975; Lester, 1975; Carpenter et al., 1980; Mayer et al., 1980; Mayer, 1981b; Rubeinstein and Firstenberg, 1987; Woods, 1987). Other researchers have determined that students who lacked the proper schemas were unable to translate the problem (Paige and Simon, 1966; Hayes, Waterman and Robinson, 1977; Hinsley, Hayes and Simon, 1977; Robinson and Hayes, 1978). In addition, algorithmic knowledge alone has been shown to be insufficient for creative problem-solving (Simon, 1980; Barszcewski, 1986; Dinnel, 1987). The problem-solving process depends upon the knowledge and use of a variety of strategies. Thus, problem-solving has as a key component, the establishment of a plan (Polya, 1968; Mayer and Greeno, 1975; Kantowski, 1977; Mayer, 1978; Mayer, Larkin and Kodane, 1980). In conjunction with the establishment of a plan, another finding was the exhibition of a preference for different styles of approach to the task (Wickelgren, 1974; Bundy, 1975; Kantowski, 1977; Larkin, 1981; Lewis, 1981; Matz, 1981; McCaulley, 1987; Woods, 1987). This research would seem to indicate that mathematics teachers should present several problem-solving approaches to their students in order to maximize their development of problem-solving abilities.

Other factors included the ability to remember and apply computational skills and conceptual knowledge previously learned, often referred to as "transfer" (Kulm and Days, 1979). Too, the conceptual understanding of the method of solution of previously solved nonroutine problems has been found to be an important factor in the solution of new nonroutine problems (Kantowski, 1974, 1980; Lester, 1975; Kulm and Days, 1979; Schoenfeld, 1985). In another set of studies (Meyer, 1978; Webb, 1979), conceptual knowledge and heuristic strategies were found to interact positively with success in problem-solving. Higher ability students tend to organize their knowledge into conceptual schema while less able students do not (Carakadon, 1978; Maxwell, 1980; Briars, 1982; Silver, 1982; Nickerson, Perkins, and Smith, 1985). This also may mean that the more able students are able to encode larger pieces of information than the less able, thereby making use of long term memory constructs rather than relying on short term memory. Additionally, there is a distinction between lower, essential skills utilizing simple recall and complex, multiple-process strategies usually required in problem-solving. Beyer (1984) distinguishes between picking out identical examples of a particular insect and finding an antidote to the sting of that same insect. The first task employs the basic processes of identification and comparison while the second requires the sequential steps of problem-solving. Hence, students not only need computational skills and a certain knowledge base, they also must have workable strategies for approaching different types of problems.

Characteristics of Problem-Solvers

All mathematics students have their share of frustrations, confusion, mental blocks, false starts and failures. Successful math students, however, have learned strategies for coping with their frustrations while the unsuccessful are defeated by them. Ruggiero (1988, pp. 74-77, 92-97, 102-109, 142-149) has attributed the following characteristics to problem-solvers:

Good Problem-solvers	Poor Problem-solvers
- Read a problem and plan an approach.	- Cannot decide how to begin and do not.
- Use previous knowledge.	- Are convinced they do not have sufficient information, often giving up or sitting passively.
- Use some type of system to approach the problem, testing hypotheses.	- Approach the problem haphazardly without testing hunches.
- Trust their reasoning skills.	- Lack confidence in their ability.
- Maintain a critical attitude, refining or correcting their solution.	- Accept their first solution and do not attempt to make improvements.

Richard R. Skemp (1979a, 1979b) and Richard E. Mayer (1981a) have emphasized the development of a conceptual structure or schema which influences the learner's approach to problem-solving. A schema has been defined as "a structure of connected concepts" (Skemp, 1979b, p. 190). Recognizing that there is a distinction between the physical world and a person's mental reality, success in problem-solving depends first on how accurately and completely the problem is conceptualized. Conceptualization involves the process of accurate perception and understanding of the problem or question, the ability to communicate the problem to others either verbally or symbolically, and the ability to break the problem into sub-areas or smaller pieces for consideration. Moreover, these conceptual perceptions must be tested and, if necessary, revised. Then, imagination allows the learner to develop a hypothesis or plan for solution which then is tested. This plan of action incorporates connections with relevant previous knowledge or existing schemas and makes a comparison of likenesses and differences. A plan of action can be the result of an intuitive process, a reflective process or a combination of the two. Often, this plan is tested mentally and examined for inconsistencies and false inferences before putting them into operation or developing a conclusion (Paige and Simon, 1966; Polya, 1968; Hayes, Waterman, and Robinson, 1977; Robinson and Hayes, 1978; Goldin and McClintock, 1979; Skemp, 1979; Mayer, 1981b; Silver, 1982, 1985, 1988).

The bulk of the research efforts on problem-solving have focused on the process and employed artificial intelligence analogies. This research in problem-solving has underscored the idea that myriad factors influence a student's success (Bengston, 1979; Lester, 1982; Case, 1988; Kilpatrick, 1988). Numerous influences on the development of problem-solving skills are not directly cognitive, but stem from other influences on human development and behavior.

Learning Theory

Learning also has been defined in many different ways. The learning process is internal and inaccessible to direct observation by the teacher. A number of researchers have examined the relationships of varied teaching methodologies, student demographic characteristics, and math anxiety to the learning of problem-solving (Sloane, 1972; Heller, 1983; Haladyna, Shaughnessey, and Shaughnessy, 1984; Kelly, 1986; Martinez de Wilkins, 1986; Billings, 1987; Ehlers, 1987, Elliot, 1987; Feliciano, 1987; Jones, 1987; Kiser, 1987; Eshenroder, 1988; Hunt, 1988; Reyes and Stanic, 1988; Hart, 1989). Others have focused on brain processes.

Our biological heritage provides us with a sequence of thinking capabilities and a set of physical tools that contribute to the establishment of problem-solving skills (Lowery, 1985). The biological development corresponding to the development of thinking skills has been documented by Monnier (1960), Eichorn and Bayley (1962), Winick and Ross (1969), and Epstein (1974). These biological studies have led to an analysis of brain functions. Brain Electrical Activity Mapping (BEAM) has made possible the collection of information on how mental processing occurs by mapping electrical impulses in the brain as tasks are completed (Cherry and Cherry, 1985). Metacognition, it is believed, involves more than an analysis of neurological impulses (Smith, 1976; Cherry and Cherry, 1985; Roth and Frisby, 1986; Schoenfeld, 1987).

Basically, researchers agree that each individual functions with two brains, the left brain and the right brain, which are linked by a complex network of nerve fibers (Bogen, 1977; Buzan, 1983). There is general agreement that each side deals with different types of mental activities and each individual has a dominant side. The right side of the brain deals with rhythm, music, images and imagination, color, parallel processing, daydreaming, face recognition, and pattern or map recognition. The left side of the brain deals with logic, language, reasoning, number, linearity, and analysis. These represent many of the problem-solving activities. McCarthy (1980) has developed a program based on preferred learning style as related to brain dominance.

Considerable doubt has been cast on the practice of relegating all of the processes used in problem-solving to one side of the brain (Goleman, 1977; Friedman and Poulson, 1981; Sternberg, 1984). A person's problem-solving potential is maximized only when both sides of the brain are developed to their potential (Cherry and Cherry, 1985; Ruggerio, 1988).

Nearly every description of learning with reference to problem-solving skills includes the significance of perception as the initial stimulus (Dewey, 1933; Hayes, 1981; Beyer, 1984; Sternberg, 1984; Ennis, 1985). It is believed that the ways in which students perceive the world influence the ways in which their essential and complex thinking processes are developed and are an integral part of the teaching-learning process. Witkin (1977) has written that a person's preferred ways of perceiving are psychologically based and account for individual differences in perception under essentially the same circumstances. He further distinguishes between two types: the field-dependent and the field-independent. The field-dependent individual's perception is dominated by the surrounding environment. The field-independent individual is able to interpret and analyze a task separately from the surrounding environment.

David R. Olsen (1976; 1985) has suggested that the development of problem-solving skills is a culture-embedded phenomenon. Robert Sternberg (1984) emphasizes the idea that thinking and learning skills depend upon information-processing which includes how people approach a task, how they plan an approach to a task, and how they actually perform the task. Sternberg, too, is concerned with understanding the student's awareness of the external world in which thinking is to be enacted. Robert Ennis (1985) also believes that much depends upon the problem-solver's interaction with the other people in his or her environment. How learners present their thinking process may be related to the metacognitive feedback that helps them make sense out of the larger environment (Baldwin, 1986; Roth and Frisby, 1986).

A concern for the development of thinking skills also has focused on the particular learning style of the student. The existence of various styles is grounded fairly well in the research literature (Gagne, 1983; Doyle and Rutherford, 1984). Similarly, the notion that teaching styles vary is also an accepted pedagogical view (Silver, 1985). These preferences play a subtle role in every classroom potentially engaged in teaching problem-solving. Bengston (1979, p. 91) has argued that the kinds of information students can process effectively hinge on their learning style. Evidence also exists to support the notion that as a part of learning style, each individual prefers to use only one perception and problem-solving process available (Witkin, 1959; Goleman, 1977; Friedman and Polson, 1981). Hence, their problem-solving skills become related to learning style. Calvano (1986) found significant differences in the learning styles of high and low achievers in the middle school (grades 6-8). Students with higher academic abilities are able to organize larger bodies of information and use multiple-processing techniques along with long-term memory to solve problems.

While it can be argued that all teaching strategies are effective for some individuals, a subtle mismatch may occur between the goals of the learner and the teacher which interferes with the demonstration of "learning" (Skemp, 1976). Thus, teaching can be termed an intervention in the learning process. This intervention may be successful or unsuccessful. Conwell (1983) found that attitudes in mathematics classes improved when teaching and learning styles were matched. Preparation for successful teaching involves not only an analysis of the conceptual structure of the subject, but an awareness of the processes of human learning and the unique schemas used by the learner in approaching a task (Skemp, 1979a, 1979b).

Type Theory

Jung (1923) has postulated that there are four basic mental processes: sensing, intuition, thinking and feeling. These four processes are used by everyone, but are not developed equally. Preference distinctions are made between each of the four processes based on the attitudes associated with each. People are motivated to use the processes they tend to prefer. Then, through practice, they develop expertise in the activities for which their preferred preferences are particularly useful (Stanfiel, 1966; Jacobi, 1968; Jung, 1971, pp. 330-333, 408-486; Hall and Nordby, 1973, pp. 96-109; Malone, 1977; Lawrence, 1979, p. 5-10). These preferences develop into characteristic habits, attitudes and traits. Further, these types are not static; they are dynamic, allowing for continued growth and development throughout life as each individual gains greater command of mental processes and functions. Jung (1971, pp. 408-486) classified the four processes under two main functions: perceptive functions and judgment functions. In relation to motivation, this dimension reveals preferred work habits (Lawrence, 1984, p. 24).

<u>Perceptive functions: sensing and intuition.</u> Sensing types, S, prefer sensing and thus develop an expertise in observational skills and a memory for facts and detail. Perception through sensing involves the use of the five senses: sight, hearing, smell, taste, and touch. Included as a characteristic is the capacity for realism, seeing the world as it exists. Attitudes associated with a preference for sensing include a reliance on experience rather than on theory and a trust of conventional or traditional. Therefore, a preference for systematically testing each new fact with past experience is developed. Moreover, relevance for practical application and working with tangibles are more important than using theory and insight (Jung, 1971, pp. 408-486; Lawrence, 1984, pp. 5-10).

In contrast, the intuitive type, N, prefers to deal with the conceptual, theoretical and symbolic relationships. Individuals with this preference develop a capacity to envision future possibilities and are considered creative. A reliance on inspiration and an interest in the new and untried develop as attitudes. Hence, a preference for learning through an intuitive development of meanings and relationships is created (Jung, 1971, pp. 408-486; Lawrence, 1984, pp. 5-10). Perception through intuition involves the unconscious incorporation of ideas and their interpretations. The sensing-intuition preference reflects basic learning style differences (Lawrence, 1979, p. 24).

Judgment functions: thinking and feeling. Jung used the term thinking, T, to define a logical decision-making process, aimed at an impersonal feeling (Hall and Nordby, 1973, pp. 96-109; Lawrence, 1984, pp. 5-10). Expertise in this area leads to the ability to analyze and examine facts objectively. The desire for logic and consistency are emphasized. Therefore, objectivity, impartiality, a sense of justice, and skill in applying logical analyses are developed as attitudes.

Looking at the opposite pole, the feeling type, F, grounds judgments in a system of personal values and standards based on a knowledge of what things matter the most to themselves and other people. The orientation is humanistic because attitudes which characterize this type include an understanding of people and an empathy with others. In addition, there is a strong desire for harmony, emphasizing a capacity for warmth and compassion along with a consideration of other people's feelings (Jung, 1971, pp. 408-486; Hall and Nordby, 1973, pp. 96-109; Lawrence, 1979, pp. 5-10). Patterns of commitments and values are shown on the thinking-feeling dimension (Lawrence, 1984, p. 24).

Attitudes toward the world: extraversion and introversion. Jung also has postulated two attitudes toward the world. The extraverted attitude, E, is characterized by sociability and an ease of communication with others. Individuals with this tendency develop a stronger awareness of and reliance on the environment for stimulation, as well as an action-oriented way to meet new events. The extravert prefers interaction, quick action, and communication. Attention is focused outward, toward objects and people in the environment (Jung, 1971, pp. 408-486; Jacobi, 1968, pp. 18-23; Lawrence, 1984, pp. 5-10).

The introvert type, I, typically spends time in contemplation and tends to limit socialization to intimates and close friends. A major interest is in clear conceptualization of concepts and ideas. There is a relative unawareness of changes in the outer situation and a discounting of their own importance in decisions (Jung, 1971, pp. 408-486; Jacobi, 1968, pp. 18-23; Lawrence, 1984, pp. 5-10). The introvert has a great capacity for sustained attention and an ability to examine complex problems in depth. Broad areas of a student's natural interest are shown by the introversion-extraversion preference (Lawrence, 1984, p. 24).

Type preference. The extraversion/introversion preference combined with the sensing/intuition preference and the thinking/feeling preference provide the eight possible combinations postulated by Jung (1971):

EST	IST
ESF	ISF
ENF	INF
ENT	INT

Each type described by Jung exhibits characteristics of both poles of the functions and both poles of the orientation toward the world. However, preferences for particular poles tend to shape the development and life choices in terms of preferred activities and career choices. Each type has certain strengths and weaknesses. Maturity in terms of type is interpreted as the capability to use whatever process is most effective in given circumstance; in other words, the ability to adapt and to take advantage of the strengths of each type.

In <u>Gifts Differing</u>, Isabel Briggs Myers (1980) explains personality differences in terms of personality development, learning preferences, academic and career choices, interpersonal relationships, and the individual's approach to the world. According to Myers, major personality differences lie in the different ways in which persons process information as reflected in the way in which they perceive and make judgments. The position is taken that personality type is innate and, as with other innate dispositions, is either fostered or hindered by environmental circumstances.

Myers-Briggs Type Indicator

The Myers-Briggs Type Indicator (MBTI) is a paper and pencil self-inventory designed to operationalize Jung's theory of type (Myers, 1962, p. 1). The items on the MBTI are forced choice and consist of word pairs, behavior reports, and value judgments. There are four dimensions or indices: EI, SN, TF, and JP. Each item pertains to one dimension and items are weighted in value. Thus, a total for each pole for each dimension is found. A comparison of the totals for each pole indicates the strength of the preference.

Developed in the 1940's by Isabel Briggs Myers and Katherine C. Briggs, the MBTI has been refined over the years and has been determined to be a valid and reliable tool for identifying an individual's personality type in a manner consistent with the theory of Jung (Carlyn, 1977; Cohen, Cohen and Cross, 1981). Myers (1962) used the split-half technique to determine the reliabilities of the scales and reported that almost all of the split-half coefficients for the indices across various groups exceeded 0.75 (p. 20). These findings have been confirmed by other researchers. Stricker and Ross (1963, 1964) reported internal-consistency reliability coefficients ranging from 0.64 to 0.84. Webb reported finding split-half reliabilities in the 0.70s and 0.80s for the raw scores with coefficients lowest for the TF scale (1964, p. 767). Webb also found a significant correlation ($p < 0.01$) between the SN and JP type classifications. Carskadon (1977) calculated test-retest correlations for 134 psychology students at Mississippi State University and found the correlations for each dimension to be significant ($p < 0.0001$) for males and females (p. 1012).

Myers (1962) verified the construct validity by correlating MBTI scores with other well-known validated personality measures. Correlations were generally significant at $p < 0.05$ or $p < 0.01$.

McCaulley (1987) has commented on five aspects of the MBTI which make it a desirable construct for identifying preferences underlying behaviors:

1. The MBTI is self-administered.
2. The items are relatively free of value-ladened questions, ambiguity, and threatening questions.
3. The MBTI can be scored by hand or computer. Scoring and analytical services are available from the Center for Applications of Psychological Type (CAPT).
4. Respondents are interested in interpretation and this interpretation is readily available for them.
5. The cost is not prohibitive.

Major Traits of the MBTI Types

First, an individual's preferred perception pattern is associated with both a sensing and an intuitive realm. A person who prefers to use the sensing realm becomes aware of the environment through the use of the five senses. This individual may be described as one who wants and trusts facts, one who is realistic and learns from experience (Kiersey and Bates, 1978). This person is practical, sensible, and realistic. The intuitive preference utilizes the unconscious in the perception process. This individual deals with possibilities, is imaginative and creative and anticipates the future. The intuitive person tends to miss the details of the present situation. Carskadon and Knudson (1978) concluded that the SN scale has construct validity when compared with the O. J. Harvey This I Believe Test for conceptual systems. Sensing types tended to be found in the lower conceptual systems.

The function of judgment determines a second basic difference in a person's mental process (Myers, 1980). Two distinct processes are used by persons in the decision-making process. Thinking has roots in a logical process and leads to an impersonal decision. The thinker values justice and fair play, but has no great need for harmony (Lawrence, 1982). Feeling revolves around a more personal judgmental process which includes personal, subjective values.

A third dimension concerns the way in which each individual relates to the environment. A person may focus on the outer world of people and things or on the inner world of concepts and ideas (Myers, 1981). The introvert relates mainly to the inner world of concepts and ideas while the extravert is directed to the outer world of people and things. Each person's perception and judgment is directed by his or her preference for introversion or extraversion.

Elizabeth Briggs Myers (1980) has added a fourth dimension, the judgment/perception (JP) preference. A judging attitude is one that makes definite decisions about situations. A perceiving attitude is one that watches a situation as it develops without making a definite decision. This dimension pertains to the way in which people prefer to use their minds. According to McCaulley (1987), the person who prefers the judgment pole needs organization and control over a task and prefers to reach closure. In contrast, the perceptive attitude favors open-mindedness, flexibility and spontaneity. This preference lends itself to postponement of decisions. Carlyn (1977) has found that the SN and JP scales of the MBTI consistently correlate with each other.

Inclusion of this fourth dimension results in sixteen different combinations possible in the Myers-Briggs typology:

ISTJ	ISFJ	INFJ	INTJ
ISTP	ISFP	INFP	INTP
ESTP	ESFP	ENFP	ENTP
ESTJ	ESFJ	ENFJ	ENTJ

In constructing the sixteen combinations, Myers (1962) suggested that while the four dimensions are independent of each other, people who demonstrate the same preferences have certain personality behaviors in common which lend themselves to the generation of verifiable predictions about behavior (Myers, 1980; McCaulley, 1987).

Preference scores on the MBTI can change slightly depending upon how an individual responds to the questions (Carskadon, 1977; Lawrence, 1982, p. 19). More specifically, these changes can occur as an individual develops or concentrates on one of the mental processes or adapts to learning methods (Campbell, 1986). Hence, that emphasis is reflected on the MBTI by a change in the preference score.

Learning Style and Typology

Several researchers (Stricker, Schiffman and Ross, 1965; Carlyn, 1977; Bloch, 1978) have concluded that the MBTI has predictive validity. Further, the MBTI profile has been shown to have a definite relationship to the choice of college major and to school achievement (Deines, 1974; Stone, 1978; Hengstler et al, 1981; Sharpe, 1988). Stricker, Schiffman and Ross found that the EI and JP scales were correlated significantly ($p < 0.01$) with GPA (1965, p. 1089). Novak and Voss (1981) and Bruhn, Bunce, and Greaser (1978) found significant relationships between type preference and I.Q.

Researchers have provided evidence that different preference types prefer different types of instruction (Cashdan and Lee, 1971; Smith, Irey and McCaulley, 1973; Smith and Irey, 1974; Roberts, 1975; Novak and Voss, 1981; Davis, 1985). Lawrence (1984, p. 24) contends that type theory reflects four areas related to student motivation. He and other researchers such as Myers (1979), Morgan (1977), and McCaulley and Natter (1978) have posed the use of type theory as the theoretical foundation for development of practical strategies for teaching which are based on the components of motivation: natural interest, learning style, values and commitments, and work habits. Morgan (1977) developed a grid of strategies for each type by examining the combinations formed from the four areas. Lawrence (1982) demonstrated that personality traits of teachers also play an important role in the learning process. Approaching learning from the point of view of the role of motivation, Lawrence has described the role of characteristics of each of the four dimensions in the learning process. Moreover, Roberts (1975) and others (Claxton and Ralston, 1978; Eason, 1986; Emley, 1986; Sharpe, 1988) contend that one of the most productive uses of the MBTI will be in aiding teachers in the development of effective learning strategies. Reaching similar conclusions, other researchers have provided suggestions for matching instructional styles to student personality type (McCaulley, 1974; Keirsey and Bates, 1978).

Each personality type has a dominant trait related to either the SN or TF preference (Myers, 1980). Dominant traits have been identified as follows:

Sensing is dominant for ISTJ, ISFJ, ESTP, and ESFP.
Intuition is dominant for INFJ, INTJ, ENFP, and ENTP.
Thinking is dominant for ISTP, INTP, ESTJ, and ENTJ.
Feeling is dominant for ISFP, INFP, ESFJ, and ENFJ.

Sensing types have been described as linear learners, preferring step-by-step, sequential approaches to learning. They prefer logical order and try to connect ideas to concrete situations in their lives. They respond when they are shown how an idea or concept can be "applied," especially a hands-on situation (Myers, 1980). These learners do well when detailed explanations are given. Roberts (1975) has suggested that sensing students have greater difficulty in grasping material that requires abstraction or mental conceptualization. Abstractions must have a concrete connection in their schema. The sensing type engages senses in the mastery of concepts and skills. Preference for sensing was found to correlate negatively with reading skill (Thomason, 1983).

Intuitives have been characterized as global learners. Intuitive types must be inspired. Routine assignments bore them. They may be characterized as daydreamers, but they are innovative when inspired and can make good use of their imaginations. The intuitive type learns well in a lecture-type situation and is able to convert words and symbols into meaning rapidly. Researchers have found that the intuitive preference correlates with highly active learners (Watson, 1985), improved logical thinking (Leising, 1986), and success in geometry (Hendrickson, 1986; Thompson, 1987). Steele (1986) describes the N type as individuals who seek a variety of ways to gain control of learning. Hinkle (1986) records a high positive correlation between the strength of the preference toward the intuitive dimension and math anxiety.

Even though Hedlund (1985) found that the SN index correlates with academic achievement and personal adaptation, Moore (1985) concluded that the SN index was not predictive of achievement for underprepared students. Examining the match between teaching styles and learning styles, Roberts (1975, pp. 5-6) found that community college instructors are predominantly intuitives (63 percent) while the students in their classes are predominantly sensors (73.5 percent). Both Reon (1984) and Wentura (1984) concluded that congruence of teaching and learning styles may be less important than course content.

The thinking types thrive on logical organized material that can be analyzed. All learning must fit into a logical mental system. They excel in a highly organized classroom and resent any learning atmosphere that does not seem to be orderly. Thomason (1988) found that T's do well in detail reading exercises. Olson (1989) reported that T's select data processing courses more often.

The feeling type need to know that the teacher "cares about" them. The caring teacher is their primary motivation and can help them complete tasks successfully which are of little interest to them. If the subject is considered "interesting," and the teacher "caring," they can become over-achievers. If neither condition is present, they will not respond to any given instructional technique. Olson found that F's have higher grades in information systems and in business courses (1988). Hinkle reported a higher degree of math anxiety among those preferring the feeling dimension.

Extraverted learners prefer interaction in the classroom and speak freely. Having a shorter attention span, often, they are quick to reach conclusions. E's have been found to prefer concrete experiences and active experimentation (Hinkle, 1986). They also score high in detail reading exercises (Thomason, 1983).

Introverted learners prefer to work in isolation, examining ideas in detail. They tend to discount their own importance and often hesitate before speaking. Hinkle (1986) reports that they exhibit skill in reflective observation and exhibit a higher degree of math anxiety. Emley (1986) found that they performed better in remedial mathematics when small groups were used. In another study, Hendrickson (1986) did not find the E/I index significant in predicting achievement in geometry.

The judging learner prefers a plan and structure to class with established goals and procedures. The preference for the judgment dimension correlates positively with comprehension and critical thinking (Thomason, 1986) and, generally, judging learners have higher GPA's (Neral (1989). J's also performed better in developmental mathematics courses (Emley, 1986).

Perceptive learners prefer the more spontaneous classroom. They are information gatherers and postpone decisions, often not attaining closure on issues. They are more adaptable and able to change with the situation (Hedlund, 1985). P's produce papers graded as average or poor more often (Held, 1983). They score lower in successive processing of information (Zaremba, 1988). In math class, they like active experimentaion (Hinkle, 1986). Lower P's have been found to be lower achievers and are at risk (Eason, 1986; Zaremba, 1988).

The following is a brief summary of learning characteristics associated with the four scales of type (Lawrence, 1982, pp. 49-55):

Extraverted Learners	Introverted Learners
- like interaction	- prefer to work alone
- like action and are quick to act	- think things through, examine events indepth and conceptualize ideas
- think out loud, speak freely	- prefer written work to oral, hesitate before speaking
- have a shorter attention span	- have a sustained attention span

Sensing Learners	Intuitive Learners
- like facts, tangible objects, reluctant to try new ideas	- like hidden meaning, possibilities, try to modify life
- present-oriented	- future-oriented
- step-by-step learning	- work with bursts of energy, have theoretical insight, study and interpret
- want to use skills learned	- like to solve new new problems, enjoy new experiences
- prefer to imitate	- creative
- realistic, practical knowledge valued	- interested in language, value words, symbols
- have keen observational skills and memory for facts and detail	- miss details, trust intutition

Thinking Learners	Feeling Learners
- like cause and effect	- examine human values and motives, humanisitc
- have perseverance	- need approval and support

Thinking Learners	Feeling Learners
- achievement-oriented, need to master subjects, task-directed	- have personal subjective values, are motivated by others, need to feel helpful
- logical, decision-making process, examine facts, seek truth, justice and fair play, may be blunt	- often agree with others for the sake of harmony, have empathy, display tact

Judging Learners	Perceptive Learners
- prefer a plan, structure to life	- prefer flexibility, spontaniety, variety, novelty to life
- prefer a known system of grading, accountability	- like autonomy and choice
- make definite decisions	- watch the development of the situation, gather information
- set goals, need control, organization and closure	- are adaptable, open-minded
- persevere	- may postpone finishing things, making decisions

Keirsey and Bates (1978) have described concisely four learning styles related to the four types: SJ, SP, NF, and NT. The SJ learners are conformists and need to feel that they belong to the group. These students adapt well to the traditional educational setting and identify the teacher as a strong authority figure. This type of student might be described as a conscientious student who has good study habits. To succeed, this student needs a consistent, stable teacher who presents sequential structured lessons. He or she must have clear directions and time to complete the task carefully. He or she is not successful in responding to open-ended situations or completing long-term, independent projects. Holtzman (1988) describes the SJ person as predominantly left-brain oriented. Hester-Voss (1982) found that the SJ students scored significantly higher on tests involving hidden patterns and on picture-completion items. The SP is more successful in active endeavors and needs to be involved physically with the learning process. This involvement may take the form of hands-on experience, performance in the classroom, or competitive events. The SP type is attracted to verbal and visual presentations. He or she dislikes and becomes bored with routine and the traditional lecture. He or she is often not successful in situations that utilize Socratic questions and traditional homework assignments that are usually found in mathematics classes. The SP type enjoys working as a part of a team and needs the stimulation of a frequent change of pace and spontaneity. He or she may be described as egalitarian and often resists the teacher's authority (Keirsey and Bates, 1978). Holtzman (1988) found the SP individual to be predominately right-brained.

The predominantly right-brained (Holtzman, 1988) NF learner requires constant feedback. It is important for such people to receive teacher acknowledgment of them as persons (Kiersey and Bates, 1978). They prefer subjects that deal with people over abstract ideas. These types of learners enjoy reading and have excellent verbal skills. They can work well in a small group or independently for a defined time period. They learn well from the discussion method, role playing, dramatic play and through fiction.

Other researchers have reported the relationship of combinations of type preferences to achievement. The extravert/sensing types were found to be low achievers (St. Germain, 1987) and to fail nursing more often (Sharpe, 1988). ITP´s and ST´s also were reported to be underachievers by St. Germain (1987). IN´s appear to do well in reading comprehension (Hester-Voss, 1982) and economics (Fish, 1984). The intuitive/perception preference correlated highly with skill on a similarities test and the thinking/judgment preference correlated with high scores in logical reasoning (Hester-Voss, 1982). Those preferring the sensing/feeling dimension combination or the sensing/judgment combination also preferred experimental learning. For general biology, general science, and chemistry high school students, Reynolds and Hope (1970) found the following results on science achievement tests:

Introverts scored higher than extraverts.

Intuitives scored higher than sensors.

Academic performance in the humanities also has been correlated with preference. Dunning (1978) found that among female students, feeling and judging types were correlated positively with academic success in the humanities while thinking types correlated with lower academic performance.

Summary

The review of the literature included a brief overview of the research on the cognitive aspects of the development of problem-solving skills. Current research has revealed the formulation of problem-solving protocols and characteristics of successful problem-solvers in terms of behaviors which result in successful problem-solving. A review of learning theory revealed the need to examine the affective variables such as attitudes and motivational patterns which influence the problem-solving strategies used by students. Researchers agree that a person's perception of a task is key to successful completion of a task. This perception is psychologically-based and related to the individual's mental processes. Jung's type theory provides the theoretical base for a comprehensive system which identifies attitudes and motivational patterns in people. Jung's theory has been operationalized by Myers and Briggs in the development and validation of the MBTI. The MBTI provides a useful construct for identifying preferences individuals have for processing information and interacting with others, elements which directly affect one's problem-solving process or learning style.

The literature review supports the premise that there is a need to explore the affective variables which guide the processing of information and the analysis of relationships among the variables of a problem. An investigation of the relationship between dimensions of preference type and the levels of problem-solving skills achieved will add to the body of knowledge on successful problem-solving.

Chapter Three

Research Design and Methodology

Chapter Three includes a statement of the purpose and rationale of the study and a restatement of the research questions and hypotheses. The research design is described along with the research instruments. The validity and reliability of the research instruments are reported. The population, sampling techniques, and data collection procedures are explained. The analyses for each research question and each hypothesis are outlined. Standard research methods are employed.

Purpose and Rationale

The purpose of this study was to investigate the relationship between significant variables related to success in mathematics by examining possible relationships between problem-solving skill level as indicated by 1) three measures of skill level: achievement level, course placement, and total score on the New Jersey Test of Reasoning Skills (NJTRS) and 2) the dimensions of type as determined by the Myers-Briggs Type Indicator (MBTI). This investigation serves to add to the educator's knowledge of the variables which impact on successful problem-solving strategies. Insight into the significant variables which can be translated into learning style preferences can guide further research in the development of effective teaching strategies in mathematics and related fields using problem-solving techniques. In particular, the emphasis of this research was to gain unbiased insight into the relationship between the way in which information is processed by students and their mathematics skill level. In this regard, three hypotheses were developed.

A secondary focus was to examine the notion presented by Roberts (1975) that sensing students have greater difficulty in mastering material that requires abstraction. If this notion were valid, it would imply that students on the lower mathematical achievement level are predominantly sensing while those at higher achievement levels are able to function intuitively. Along with this concept, three additional hypotheses related to the preferred dimension for the extraversion/introversion, the thinking/feeling, and the judgment/perception indices were tested.

Research Questions

The literature review in Chapter Two provided the rationale for addressing three research questions:

Research Question 1: Is there a relationship between the dimensions of type as measured on the MBTI and mathematical achievement level as indicated by placement in one of three mathematics course levels among community college students?

The four indices of type served as the independent variables. Student achievement, the dependent variable, was indicated by three mathematics achievement levels: developmental, prealgebra, and college level.

Research Question 2: Is there a relationship between the dimensions of type as measured on the MBTI and course level as indicated by placement criteria among community college students?

The four indices of type were the independent variables while course of enrollment, organized in order according to the existing prerequisite system, was the dependent variable.

Research Question 3: Is there a relationship between dimensions of type as measured on the MBTI and problem-solving ability as indicated by total score on the New Jersey Test of Reasoning Skills?

The New Jersey Test of Reasoning Skills (NJTRS) has been shown to correlate with mathematics placement or skill level (Lipman, 1984). Examination of variance in student scores on this indicator as explained by student MBTI dimension preferences served as a second avenue to explore the relationship of problem-solving skill to preference type.

Hypotheses

Three hypotheses were posed to test the predictive value of the indices of type to each of the dependent variables included in the research questions. Then, four hypotheses were posed to describe specific relationships between achievement level and each index of type.

Hypothesis 1: The indices of the MBTI interact significantly to predict achievement level.

Hypothesis 2: The indices of the MBTI interact significantly to predict course level.

Hypothesis 3: The indices of the MBTI interact significantly to predict problem-solving ability.

Hypothesis 4: Students in developmental level courses demonstrate a stronger preference toward the introversion dimension of the extraversion/introversion index than students in the higher level courses.

Hypothesis 5: Students in developmental level courses demonstrate a stronger sensing preference on the sensing/intuition index than students in the higher level courses.

Hypothesis 6: Students in developmental level courses demonstrate a stronger thinking preference on the thinking/feeling index than students in the higher level courses.

Hypothesis 7: Students in developmental level courses demonstrate a stronger preference in the judgment direction of the judgment/perception index than students in the higher level courses.

The hypotheses posed were based on observations of the students in developmental mathematics classes and supported by the descriptions of learning style submitted by Morgan (1977) and the ideas presented by Roberts (1975).

Exploratory Research Design

To explore the research questions, this research design involved an exploratory field study aimed at ascertaining whether any relationship exists between the dimensions of type, as measured on the MBTI, and problem-solving abilities, as indicated by mathematics skill level and reasoning skills in adult learners. Field studies of this type employ *ex post facto* designs best-suited to exploring the relationships and interactions among psychological and educational variables (Kerlinger, 1973, p. 405). However, certain limitations should be recognized. The limitations cited by Kerlinger (1973, pp. 390-391) include:

1. The inability to control or manipulate the independent variable.
2. The inability to randomize subjects into groups.
3. A high risk of misinterpretation due to the risk of a small N for each cell or intervening factors such as language barriers or learning disabilities which have not been identified and are not included in the analysis.

The researcher made no attempt to control or manipulate the independent variables as these variables constituted already existing personality traits and preferences. According to Kerlinger (1973, p. 379), ex post facto research involves inquiry in which the independent variables may be neither controlled nor manipulated because they are inherent in the subjects. Thus, any inferences made about the relationships between the dependent and independent variables must be made without direct intervention. Another characteristic of this design involves the inability to assign subjects to groups at random (Kerlinger, 1973, p. 380). The subjects were in groups in part because they have certain characteristics in common and in part because they were self-assigned. Self-assignment was limited to groups or classes within a subset of groups determined by their shared characteristics. Furthermore, in conducting an exploratory field study to address the research questions, the researcher can focus on determining "what is" rather than on predicting relationships to be found (Kerlinger, 1973, p. 406). While this type of exploratory investigation can be conducted without hypotheses (Kerlinger, 1973), such explorations into relationships can lead to hypothesis-development and testing. However, in addition, this study included hypotheses based on implications from the literature.

Research Instruments

Three instruments were administered to all students. First, two forms of the New Jersey College Basic Skills Placement Test (NJCBSPT) were administered before the start of classroom instruction. Second, the New Jersey Test of Reasoning Skills (NJTRS) was administered. Third, the Myers-Briggs Type Indicator (MBTI) was administered.

The first instrument administered, the New Jersey College Basic Skills Placement Test (NJCBSPT), established the mathematical skill level of students. Two forms of the NJCBSPT were used to ensure proper placement in mathematics courses. In all cases, placement was checked for consistency with high school achievement in mathematics.

On the college level, mathematics course placement and enrollment are based on results of the NJCBSPT coupled with high school achievement record or verification of successful completion of prerequisite courses. The NJCBSPT was designed in 1977 with two purposes: 1) to provide a measure of skill level to be used to place students in appropriate freshmen courses and 2) to monitor the degree of preparedness in the areas of reading, writing, computation, and algebraic concepts of these entering students (Results of the New Jersey College Basic Skills Placement Testing, 1988, p. 1). The level of skills tested is considered minimal for students graduating from high school. Each March, a new form of the test, developed by a panel of New Jersey educators in concert with the Educational Testing Service in Princeton, New Jersey, is issued. Each form is equated statistically with previous forms (Department of Higher Education, 1988, p. 3).

The arithmetic and algebraic portion yield individual raw scores which are converted to scaled scores. These scaled scores have essentially the same meaning for all forms of the test. State guidelines and analysis of these two scores determine initial placement. A scaled score of 164 or less on the computation section indicates a lack of proficiency in arithmetic skills. These students must enroll in the lowest level developmental arithmetic course, Computational Arithmetic I. A scaled score between 165 and 172 indicates proficiency in some areas. Students scoring in this range enroll in the second level developmental course, Computational Arithmetic II.

Students who achieve a score of 174 or greater on the computational portion <u>and</u> a scaled score of 166 or less on the algebra portion have an understanding of arithmetic, but lack proficiency in algebraic reasoning. These students must enroll in an elementary algebra course.

Students who score between 167 and 182 on the algebra portion have some weaknesses and may enroll in a faster paced elementary algebra course. Students who are able to achieve a scaled score above 183 on the algebra portion are determined to be proficient and may enroll in college level mathematics courses.

As a verification of student abilities, a second form of the test is given on the first day of classes. Based on these results and, if necessary, analysis of high school records, students may be reassigned to classes. This reassignment may involve movement to a lower level class as well as to a higher level class. Students who are not entering freshmen, must complete prerequisite courses successfully with a mastery grade of 80% or higher. Students who have not met the prerequisite requirements are transferred to appropriate courses when the retest is administered to entering students. Thus, mathematical skill level is determined. Additionally, students enrolled in college level courses are assigned to specific courses according to the mathematics requirement for their degree major. Each of the college level courses included in the study meets the minimal mathematics requirement for graduation. Thus, students entering on one of the lower levels must take the inclusive sequence of courses before entering the college level courses.

The second instrument administered, the New Jersey Test of Reasoning Skills (NJTRS), has been shown to correlate highly with the New Jersey Basic Skills Placement Test and, in this investigation, was used to verify correct course placement as well as to provide a measurement of reasoning skills. This 50-item multiple choice instrument was developed in 1983 by Dr. Virginia Shipman, Senior Research Psychologist, Educational Testing Service, Princeton, New Jersey (Totowa Board of Education, 1985). The purpose of the test is to assess reasoning skills of students based on 22 criteria. Total test score results have been correlated with the New Jersey College Basic Skills Placement Test. The correlation is r = 0.67 on the arithmetic portion and 0.59 on the elementary algebra portion (Lipman, 1984). Therefore, only the total score was used for the purpose of this study. The test concentrates on reasoning without relying on content, vocabulary or recollection of facts to complete the task. The test is written clearly in dialogue form. Test reliability for grades 7 and higher has been established at 0.91 and above (Morante and Ulesky, 1984).

The third instrument administered, the Myers-Briggs Type Indicator (MBTI), was developed by Isabel Briggs Myers in the 1940's. The purpose of the MBTI is to operationalize Jung's theory of type (1923). The instrument employs self-reporting of preferences as related to four dimensional scales. The MBTI has been shown to be a reliable and valid instrument for identifying a person's personality type and learning style (Cohen, Cohen, and Cross, 1981; Carlyn, 1977). Scoring of the MBTI results in numerical scores for each of four dimensional scales. The instrument may be scored by hand or by computer.

Form F of the MBTI was used in this study. This form contains 126 forced-choice items consisting of word pairs, behavior reports, and non-threatening value judgments. Each of the items pertains to only one of the four indices: EI, SN, TF, or JP. Each item used in the analysis is weighted. The respondent's results are summed for each dimension of each index separately. Hence, the results for each respondent consist of eight numerical values, two for each index. Comparison of these two values determines first, the preference and second, the strength of the preference. For each index, the larger of the two numbers determines the individual's preference. When the dimension preference has been determined for all four indices, the four letters indicating the preference on each index comprise the individual's preference-type. The MBTI also was used to obtain two demographic variables: age and gender.

Population and Sample

In this study, the population consisted of the heterogeneous cohort of community college students in New Jersey. Atlantic Community College was selected for three reasons. The student population reflects the full range of achievement, social, economic, and ethnic variables of the typical community college student (Results of the New Jersey College Basic Skills Placement Testing, 1986; Lee, 1985; Gilbert, 1979). Moreover, even though the college is located in a rural area, it is the regional center for a number of unique programs of study, and the student body includes not only students from all areas of the state but also a number from other states as well. Since the researcher also teaches at Atlantic Community College, the data collection procedure was deemed more feasible and it was felt that any forthcoming recommendations would be implemented.

The sample tested was selected by randomly choosing sections from each of the freshman level courses offered in the fall semester, 1986. The sample was limited further to students who had completed all parts of the data collection procedure. A sample of 577 mathematics students was selected from a population of 1,137 students enrolled in mathematics courses. The positively skewed distribution of ages ranged from 16 to 48 years. There were 315 females and 262 males in the study. The average age in the sample was 21.8 with a standard deviation of 5.4.

Data Collection Procedure

The data collection was accomplished in three stages. The first stage involved the verification of mathematics skill level and identification of achievement level and course level using the New Jersey College Basic Skills Placement Test. The second stage involved the collection of a measure of student problem-solving ability as measured on the New Jersey Test of Reasoning Skills. The third stage provided the identification of preference type through the administration of the Myers-Briggs Type Indicator. All data collection procedures were conducted during class meeting times. Students who were absent were asked to contact the researcher to complete any portion missed.

Mathematical Skill Level: Identification of mathematical skill level involves several steps. First, all entering students must complete the New Jersey College Basic Skills Placement Test (NJCBSPT) prior to admission to the college. This instrument is used to assess skill levels in four basic areas: reading level, writing skills, arithmetic skill level, and algebraic skills and reasoning. Based on these results, students are placed in beginning courses. Students strongly are advised to complete the communications sequence (reading, writing, and communications) and the mathematics sequence during the first semesters enrolled. In the mathematics area, students may be placed on one of three basic levels:

1 Developmental: no proficiency in arithmetic concepts.

2 Prealgebra: proficiency in arithmetic and no algebraic skills.

3 College Level: ability to enter college level mathematics coursework.

Each of the three achievement levels was given an ordinal designation according to heirarchical skill.

Within each of these levels, students are placed in courses. Each achievement level is broken down into two course levels which were given ordinal designations based on difficulty level and the existing prerequisite system. Three courses had the same prerequisite and were given the same number. The ranking was:

Developmental: 1 Computational Arithmetic I

2 Computational Arithmetic II

Prealgebra: 3. Elementary Algebra (two semesters)

4 Elementary Algebra (one semester)

College Level: First course level (equivalent courses assigned according to major):

5 Liberal Arts Math

5 Statistics

5 Intermediate Algebra

Second course level:

6 College Algebra

In addition, students in the developmental or elementary algebra courses are retested on the first day of class to verify placement. At this time, high school records are examined and students are interviewed by the mathematics faculty for consistency with placement. In college level courses, placement scores and high school preparation are verified along with completion of any required prerequisites. As a result of this assessment, students may be transferred either up or down in the hierarchy of mathematics courses. While students may self-select, to some extent, the time and the instructor, the course level is verified and determined through a series of checks and balances.

Reasoning Skills Test: Form B of the New Jersey Test of Reasoning Skills was administered during the first week of the semester by the classroom instructor. The Educational Testing Service (ETS). scored the tests and compiled an itemized profile for each student. Only the total score was used in the data analyses.

Myers-Briggs Type Indicator: Form F of the MBTI was administered during the third and fourth weeks of the semester by counselors trained in the administration of the profile. The completed inventories were hand scored by the researcher and checked by an assistant. The scores were converted as described in Figure 3.2. The MBTI profile was determined by index preference. Each of the sixteen profiles was assigned a nominal number.

The MBTI inventory included gender and age for each student. While age and gender did not relate directly to the research questions, these two variables contributed to the characteristics of the sample. Age was recorded to the nearest year. Gender was indicated in the data by the verified along with completion of any required prerequisites. As a result of this assessment, students may be transferred either up or down in the hierarchy of mathematics courses. While students may self-select, to some extent, the time and the instructor, the course level is verified and determined through a series of checks and balances.

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Myers-Briggs Type Indicator: Form F of the MBTI was administered during the third and fourth weeks of the semester by counselors trained in the administration of the profile. The completed inventories were hand scored by the researcher and checked by an assistant. The index scores were converted to continuous scores and the MBTI profile was determined by index preference. Each of the sixteen profiles was assigned a nominal number.

The MBTI inventory included gender and age for each student. While age and gender did not relate directly to the research questions, these two variables contributed to the characteristics of the sample. Age was recorded to the nearest year. Gender was indicated in the data by the

Research Question	Method Used	Dependent Variable	Independent Variable(s)
1	. Crossbreaks . Chi Square	Achievement	Indices of Type
2	. Crossbreaks . Chi Square	Course	Indices of Type
3	. Chi Square . Correlations	NJTRS	Achievement Level and Course
	. Chi Square	NJTRS	Indices of Type Age Gender

Hypothesis	Method Used	Dependent Variable	Independent Variable(s)
1	. Spearman rho . Discriminant Analysis	Achievement Level	Indices of Type
2	. Spearman rho . Discriminant Analysis	Course	Indices of Type
3	. Multiple Regression	NJTRS	Indices of Type
4	. Correlation	Achievement Level and Course	E/I Index
5	. Correlation	Achievement Level and Course	S/N index
6	. Correlation	Achievement Level and Course	T/F index
7	. Correlation	Achievement Level and Course	J/P index

FIGURE 3.1

ANALYSIS TECHNIQUES

level. Using the prerequisite order, these courses were numbered consecutively from lowest to highest: numbers 1 to 5.

The total score for the Test of Reasoning Skills was used. This score was in the form of a raw score value: number correct out of a total possible of 50.

The profile scores for the MBTI were converted into continuous scores using the conversion format recommended by Myers (1962, p. 9). First, the difference between the two dimensions of the index was computed. After the preference was identified by a letter notation, this difference in points was converted to a preference score (Myers, 1962, p. 8). For the I, N, F, and P preference, the continuous score is the preference score plus 100. For the E, S, T, and J preference, the continuous score is 100 minus the preference score. Students with an index score above 100 were characterized by the I, N, F, and P respectively. A score of less than 100 indicated a preference of E, S,T, and J respectively. The strength of the preference is indicated by the amount the score deviates from 100. This continuous score was used when a comparison was made of the indices of type to other variables. Figure 3.2 provides an example of the conversion technique. This process created four additional variables which were used in place of the individual profile scores for each of the eight dimensions of type. Moreover, a profile of type was determined for each participant.

Step One:	Determine the points for each dimension of type.
Step Two:	Identify the dimension preference for each index by letter.
Step Three:	Find the difference between the points for each dimension of each index and convert to preference scores using the conversion chart developed by Myers (1962, p. 8).
Step Four:	If the preference is I, N, F, or P, add 100 to the preference score. If the preference is E, S, T, or J, subtract the preference score from 100 (Myers, 1962, p. 9). A score above 100 indicates the I, N, F or P preference. A score below 100 indicates the E, S, T, or J preference.

Student #2: Female

Points		Profile Scores		
		Letter	Difference	Converted Score
E 09	I 15	I	06	13
S 25	N 09	S	16	31
T 06	F 11	F	05	11
J 13	P 14	P	01	03

Profile and Continuous Scores of Student # 2:

I	113
S	69
F	111
P	103

FIGURE 3.2

DEVELOPMENT OF CONTINUOUS SCORES

FOR THE MYERS-BRIGGS TYPE INDICATOR

Each of the research questions was addressed in turn. Then, each hypothesis was tested for significance.

First, the relationship of achievement level to the indices of type was investigated. To respond to this question, two-dimensional crossbreak tabulations were completed comparing achievement level by index preference. For each, a Chi Square Test for Independence was undertaken and the results were reported. The dependent variable for this question was achievement level and the independent variables were preference scores for the indices of type. Next, the possibility of a straight line relationship between achievement level and the indices of type was examined by computing and testing Spearman rho for each. To study the combinational relationships among these variables, a stepwise discriminant analysis was conducted for the achievement levels using the MBTI preference scores as functions. The purpose was to give the researcher a picture of the differences in achievement level as determined by indices of type and to test the significance of the interactions of the indices of type as a predictor model for achievement level. Similar steps were taken in the analysis of the relationship between course and the dimensions of type.

The relationship between the results of the NJTRS and the dimensions of type was inspected through two major analysis techniques. Before addressing this research question, a comparison of the results of the NJTRS and mathematical skill level as well as course was completed. Since the numerical values for both the placement level and course were ordinal, the Spearman rho was tested for significance. Next, the results of the NJTRS were compared to each index of type by means of the Chi Square Test of Independence. For this question, the variables examined were interval in nature. Consequently, multiple regression analyses were performed to determine significance of predictor relationships between NJTRS and MBTI preference scores.

For each of the latter four hypotheses, correlations were tested for significance using both achievement level and course as dependent variables and each index of type as independent variables.

One post-hoc analytic procedure was undertaken. This analysis of the combination of two indices of type stemmed from the information and results derived from the original procedures.

First, the distribution in the sample of the combinations of the S/N and J/P indices was tested for Goodness of Fit. Then, the proportion of each of the combinations according to achievement level was examined for independence.

In addition to exploring the relationships outlined in the research questions and the hypotheses, the distribution of the variables in the sample was investigated. The results of the test for Goodness of Fit and other descriptive statistics were included. These tests provided a description of the characteristics of the sample.

Summary

The research methodology for the study was presented in this chapter. The purpose and rationale of the study and the research questions and hypotheses were stated. The research questions focused on the primary objective of the study which was to explore the possible relationship between the dimensions of type and mathematical skill level and reasoning skill level. A description of the _ex post facto_ field study was followed by a discussion of the research instruments and their validity and reliability. It was determined that the instruments were adequately reliable and valid for the intended purpose. Descriptions of the population and sample as well as an explanation of the data collection procedures were offered. The methods of analysis used for each research question and each hypothesis were presented.

CHAPTER FOUR

The Results of the Investigation

Introduction

Chapter Four presents the findings of the study. Included are a total of ten tables to summarize findings which are presented in narrative form as well.

Research Question 1

Is there a relationship between the dimensions of type as measured on the MBTI and mathematical achievement level as indicated by placement in one of three mathematics course levels among community college students?

Using several types of analysis, mathematical achievement level was compared to each index of type. The first step in the analysis involved the generation of crossbreak tabulations for achievement level by preferred dimension of each index of type. A series of Chi Square tests were examined for significant associations. Examination of the preferences on each of the four indices of type demonstrated a significant association of the S/N index and levels of achievement. For this index, the Chi Square value was found to be 12.214, significant at $p < 0.01$. Next, the Spearman rho was found to be significant at the 0.01 level (rho = 0.17). Table 4.1 summarizes the distribution of the dimensions of type preferred by achievement level and the statis-

Table 4.1

Relationships Between the Indices of Type and Achievement Level

Dimensions of Type		Achievement Levels: Developmental	Prealgebra	College Level
1.	E	22.7%	18.0%	13.2%
	I	21.4%	16.1%	8.7%
2.	S	33.4%	24.4%	12.8%
	N	10.6%	9.7%	6.8%
3.	T	22.7%	16.6%	10.1%
	F	21.3%	17.5%	11.8%
4.	J	24.8%	15.6%	10.2%
	P	19.2%	18.5%	11.6%

Statistical Results for the Indices of Type by Achievement Level

Index	Chi Square	Probability	Spearman rho	Probability
E/I	2.738	0.254	-0.033	not significant
S/N	12.214	< 0.01	0.117	< 0.01
T/F	1.088	0.580	0.004	not significant
J/P	5.922	0.052	0.061	< 0.10

tical analysis for each index.

While not significant at the 0.05 level, the result for the Judgment/ Perception index appeared to be interesting. For this index, Chi Square was equal to 5.922 with $p = 0.052$. Too, examination of the Spearman rho produced results significant at the 0.10 level (rho = 0.061). While this was not a strong relationship, it was stronger than the remaining two indices.

<u>Research Question 2</u>

Is there a relationship between the dimensions of type as measured on the MBTI and course level as indicated by placement criteria among community college students?

The same series of analysis techniques completed for Research Question 1 were repeated for investigating the relationships between the dimensions of type and the courses within each achievement level. With this breakdown of achievement level, both the S/N and J/P indices had a significant association. The Chi Square Test of Independence was 23.3, $p < 0.01$ for the S/N index and 19.973, $p < 0.01$ for the J/P index. When the Spearman rho for these two indices with course as the dependent variable was computed, only the S/N index produced significant results (rho = 0.105, $p < 0.05$). Table 4.2 presents a summary of the statistics for all four indices by course.

Table 4.2

Relationships Between the Indices of Type and Course

Dimensions of Type		Courses 1	2	3	4	5	6
1.	E	9.7%	13.0%	10.1%	8.0%	10.6%	2.6%
	I	10.1%	11.3%	10.1%	6.1%	6.8%	1.9%
2.	S	15.4%	18.0%	13.7%	10.7%	10.2%	2.6%
	N	4.3%	6.2%	6.4%	3.3%	7.1%	1.9%
3.	T	9.2%	13.5%	9.0%	7.6%	7.6%	2.4%
	F	10.6%	10.7%	11.1%	6.4%	9.7%	2.1%
4.	J	10.6%	14.2%	9.0%	6.6%	6.8%	3.5%
	P	9.2%	10.1%	11.1%	7.5%	10.6%	1.0%

Statistical Results for the Indices of Type Course

Index	Chi Square	Probability	Spearman rho	Probability
E/I	4.443	0.728	-0.049	not significant
S/N	23.300	< 0.01	0.105	< 0.05
T/F	12.380	0.089	-0.017	not significant
J/P	19.973	< 0.01	0.034	< 0.10

Research Question 3

Is there a relationship between dimensions of type as measured on the MBTI and problem-solving ability as indicated by total score on the New Jersey Test of Reasoning Skills?

Research Question 3 was posed to provide a second way to ascertain whether problem-solving skill could be related to MBTI type. Before investigating relationships between MBTI type and the test score on the reasoning skills test, the correlation between achievement level and the reasoning skills test score was examined. Then, student scores on the NJTRS were compared to MBTI type and to each of the indices of type.

The Chi Square Test of Independence for Achievement Level and the NJTRS and for Course and the NJTRS resulted in a Chi Square of 60.1782 and 109.3401. Both of these comparisons were significant at the 0.0001 level. The results of the NJTRS and achievement level were correlated positively at the 0.00001 level ($r = 0.245322$). Similarly, when the correlation between the reasoning skills test score and course was analyzed, the results were significant at $p < 0.00001$ ($r = 0.218975$). These results supported the belief that the reasoning skills test would provide an alternative approach to exploring the relationship between MBTI type and problem-solving skills.

The Chi Square analysis of the association of the NJTRS and the indices of type revealed the S/N index significant at $p < 0.0001$ (Chi Square = 53.629). None of the other three indices was significant at the 0.05 level. However, for the NJTRS, the T/F index emerged as significant at the 0.10 level. Also analyzed for the NJTRS were age and gender. Neither proved to be significant at the 0.05 level. Table 4.3 presents a summary of the results for these findings for the NJTRS test scores.

Hypotheses

A stepwise discriminant analysis was conducted to test the first two hypotheses and a multiple regression was conducted for the third hypothesis. Two correlation coefficients were computed to test each of the remaining four hypotheses. For these, the Spearman rho was tested for each index with achievement level as the dependent variable. Then, the test was repeated for each index with course as the dependent variable.

Hypothesis 1

The indices of the MBTI interact significantly to predict achievement level.

A stepwise discriminant analysis was conducted to determine which of the indices of type, the independent variables, account for most of the differences in achieve-

Table 4.3

Analysis Summary for the New Jersey Test of Reasoning Skills

NJTRS and Skill Level Variables:

Variable	Chi Square	P	Correlation	P
a. Achievement Level	60.178	< 0.0001	0.245	< 0.00001
b. Course	109.340	< 0.0001	0.219	< 0.00001

NJTRS and Student Characteristics

Variable	Chi Square	Probability
1. Indices of Type:		
EI	11.937	0.217
SN	53.629	< 0.00001
TF	14.856	0.095
JP	14.244	0.042
2. Age	166.538	0.517
3. Gender	10.493	0.105

ment level. Using the automatic procedure, the first step included the S/N index. Inclusion of the S/N index resulted in a F-ratio significant at the 0.01 level. Positively related to achievement, this variable accounted for 14.7 percent of the variance. The J/P index contributed another 13.2 percent. Inclusion of the remaining two indices contributed less than 10 percent to R square. Table 4.4 contains the results of this discriminant analysis.

<u>Hypothesis 2</u>

The indices of the MBTI interact significantly to predict course level.

Again, a stepwise discriminant analysis was conducted to determine which of the independent variables account for most of the difference in achievement level when described by course. The S/N index in the first step and the J/P index in the second. The F-ratio for the S/N index was significant at the 0.01 level and the variable was positively related to achievement level, which accounted for 14.7 percent of the variance. J/P explained an additional 13.2 percent ($p < 0.05$) of the variance. No other variable contributed as much as 10 percent to R square. Table 4.4 presents findings for this stepwise multiple regression analysis.

Table 4.4

Discriminant Analysis

Variable Selection Report

Classification Variable: Achievement Level

Variable	F-Ratio	F-Probability	R Square
SN	6.8	0.0012	0.1471
JP	2.0	0.1352	0.1316
TF	0.4	0.6589	0.0258
EI	0.0	0.9801	0.2580

Classification Variable: Course

Variable	F-Ratio	F-Probability	R Square
SN	2.9	0.0142	0.1471
JP	2.9	0.0138	0.1316
TF	0.5	0.7753	0.0258
EI	0.4	0.8666	0.0350

Hypothesis 3

The indices of the MBTI interact significantly to predict problem-solving ability.

A stepwise multiple regression analysis was pursued with the NJTRS score processed as the dependent variable and MBTI preference scores as predictors. As with Hypotheses 1 and 2, the S/N index accounted for more of the variance than the other measures. The S/N index accounted for 4.9 percent of the variance and the J/P index accounted for 2.2 percent. Each of the other variables accounted for less than 0.5 percent of the variance. Correlation of the NJTRS with the S/N index and with the J/P index resulted in positive correlations significant at the 0.001 level for each. Table 4.5 presents a summary of the results of the findings for the NJTRS test scores.

Hypothesis 4

Students in developmental level courses demonstrate a stronger preference toward the introversion dimension of the extraversion/introversion index than students in the higher level courses.

The correlation coefficient with the E/I index as a predictor for achievement level was - 0.033. When used as a predictor for course, the correlation with the E/I index was - 0.487. Neither coefficient proved to be significant. These results are summarized in Table 4.6.

Table 4.5

NJTRS and Student Characteristics

Variable	Correlation	Probability	R Square
1. Indices of Type:			
EI	-0.445	not significant	0.0020
SN	0.221	< 0.001	0.0487
TF	0.865	not significant	0.0075
JP	0.147	< 0.001	0.0217
2. Age	0.042	not significant	0.0018
3. Gender	-0.159	< 0.001	0.0033

Analysis of Variance Report for NJTRS

df	Sums of Squares	Mean Square	F-Ratio	Probability	R Square
6	1599.287	266.548	6.22	< 0.001	0.0614
576	26030.2	45.191			

Table 4.6

Tests of Hypotheses

Dependent Variable	Independent Variable	Spearman rho	Probability
1. **Achievement Level:**	**E/I Index**	- 0.033	0.215
	S/N Index	0.117	0.003
	T/F Index	0.004	0.460
	J/P Index	0.061	0.074
2. **Course:**	**E/I Index**	- 0.049	0.119
	S/N Index	0.105	0.006
	T/F Index	- 0.017	0.341
	J/P Index	0.034	0.206

Hypothesis 5

Students in developmental level courses demonstrate a stronger sensing preference on the sensing/intuition index than students in higher level courses.

Using the sensing/intuition index as a predictor of achievement level resulted in a correlation coefficient of 0.117, significant at the 0.01 level. When compared to course, the correlation coefficient was 0.105, also significant at the 0.01 level. The positive sign in each test indicated that the stronger the score in the direction of the sensing dimension, the lower the skill level. The hypothesis was confirmed. Table 4.6 provides a summary of these results.

Hypothesis 6

Students in developmental level courses demonstrate a stronger thinking preference on the thinking/feeling index than students in higher level courses.

The thinking/feeling index did not emerge as a significant predictor of either achievement level or course. The correlation coefficients were 0.004 and -0.017 for achievement level and course respectfully. The statistical analysis for this hypothesis is shown in Table 4.6.

Hypothesis 7

Students in developmental level courses demonstrate a stronger preference in the judgment direction of the judgment/perception index than students in the higher level courses.

When the judgment/perception index was used as a predictor of achievement level and as a predictor of course, the coefficient was not significant at the 0.05 level. However, the probability for the J/P index as a predictor of achievement level was less than 0.10. These findings are summarized in Table 4.6.

Post Hoc Analysis

The emergence of the S/N index and the J/P index as significant predictors led the researcher to investigate the distribution of the four combinations created by these two indices: SJ, SP, NJ, and NP. Of these combinations, the majority of students were in the SJ category (236 students). A Chi Square Goodness of Fit Test resulted in a Chi Square value of 124.456 for a $p < 0.001$. The Test for Independence of Proportions for the four combinations and achievement level produced a Chi Square of 17.101, significant at the 0.01 level. The same test for the four combinations and course yielded a Chi Square of 56.403, $p < 0.001$. Table 4.7 provides the results of these analyses.

Table 4.7

Combinations of the S/N Index and the J/P Index

Test for Goodness of Fit

Combination	N	%
SJ	236	40.9%
SP	172	29.8%
NP	113	19.6%
NJ	56	9.7%

Chi Square: 124.456

$p < 0.001$

Test for Indpendence of Proportions

Combination		Achievement Level 1		2		3
SJ	N	118	N	72	N	46
	% Level	46.5%	% Level	36.9%	% Level	35.9%
	% Total	20.5%	% Total	12.5%	% Total	8.0%
SP	N	75	N	67	N	30
	% Level	29.5%	% Level	34.4%	% Level	23.4%
	% Total	13.0%	% Total	11.6%	% Total	5.2%
NP	N	36	N	40	N	37
	% Level	14.2%	% Level	20.5%	% Level	28.9%
	% Total	6.2%	% Total	6.9%	% Total	6.4%
NJ	N	25	N	16	N	15
	% Level	9.8%	% Level	8.2%	% Level	11.7%
	% Total	2.6%	% Total	2.8%	% Total	4.3%

Chi Square: 17.101
$p < 0.01$

Chi Square of Combinations by Course: 56.403
$P < 0.001$

Characteristics of the Sample

To aid in determining the applicability and generalizability of the results, additional tests were conducted in an effort to extract descriptive information about the sample. These additional tests included both quantitative and descriptive analyses of each of the variables alone or in concert with other descriptive variables. Variables explored included the distribution of the sample with regard to achievement level and course, the distribution of the MBTI profiles, and preference dimension for each index of type. Also, age and gender were compared to several variables.

Distribution of Sample by Achievement: In the sample, 44.0 percent were tested at the developmental level, 34.1 percent tested at the prealgebra level, and 21.8 percent tested at college level. Overall in the population, 42.6 percent were enrolled in the developmental level courses, 35.7 percent were enrolled in the prealgebra level, and 19.9 percent were enrolled in college level courses.

MBTI Profiles in the Sample: Each of the sixteen MBTI profiles was found in the sample. ESTJ was the most abundant profile with 11.1 percent of the sample. ISTJ described the profile of 10.7 percent of the sample. Thus, the STJ preference accounted for a total of 21.8 percent of the sample. The preference type ISFJ accounted for 10.6 percent of the sample. Performance of the Chi Square Test of Goodness of Fit resulted in a Chi Square value of 142.667 with 15 degrees of freedom. This result was significant at $p < 0.001$. Table 4.8 provides a summary of the distribution of type for the sample and Table 4.9 shows the distribution of Type according to achievement level.

Dimension Preferences for the Indices of Type: The indices of type were analyzed for the sample as well. Preference for the dimensions of the four indices of type were distributed almost evenly for the Extraversion/ Introversion (E/I) index, the Thinking/Feeling (T/F) index and the Judgment/Perception (J/P) index. The Sensing/Intuition (S/N) index exhibited 70.7 percent preference for sensing compared with 29.3 percent preference for intuition. The Goodness of Fit Test for this index resulted in a Chi Square of 98.17 ($p < 0.001$). Table 4.9 indicates the distribution for the sample and the results of the Test for Goodness of Fit.

Age: The positively skewed distribution of age for this sample was examined. The average age was 21.8 and the median was 20. A test for association of age and achievement level produced a Chi Square of 84.0815 significant at $p < 0.01$. Likewise, age and course were associated significantly at $p < 0.01$. The Chi Square for age by course taken was 248.1978. The age distribution for each achievement level appears in the appendix. An examination of the association between age and the NJTRS did not yield significant

Table 4.8

Distribution of MBTI Type in the Sample

(N = 577)

ISTJ	N	%	ISFJ	N	%	INFJ	N	%	INTJ	N	%
male	32	12.2	male	14	5.3	male	3	1.1	male	8	3.1
female	30	9.5	female	47	14.9	female	5	1.6	female	2	0.6
totals	62	10.7	totals	61	10.6	totals	8	1.4	totals	10	1.7
ISTP	N	%	**ISFP**	N	%	**INFP**	N	%	**INTP**	N	%
male	26	9.9	male	12	4.6	male	12	4.6	male	14	5.3
female	10	1.5	female	31	9.8	female	15	4.8	female	5	1.6
totals	36	6.2	totals	43	7.5	totals	27	4.7	totals	19	3.3
ESTP	N	%	**ESFP**	N	%	**ENFP**	N	%	**ENTP**	N	%
male	34	13.0	male	13	5.0	male	6	2.3	male	14	5.3
female	15	4.8	female	31	9.8	female	37	11.7	female	10	3.2
totals	49	8.5	totals	44	7.6	totals	43	7.5	totals	24	4.2
ESTJ	N	%	**ESFJ**	N	%	**ENFJ**	N	%	**ENTJ**	N	%
male	39	14.9	male	17	6.5	male	7	2.7	male	11	4.2
female	25	7.9	female	32	10.2	female	10	3.2	female	10	3.2
totals	64	11.1	totals	49	8.5	totals	17	2.9	totals	21	3.6

Test for Goodness of Fit: 142.667

$p < 0.001$

Table 4.9

Preference Type by Achievement Level

	ISTJ		ISFJ		INFJ		INTJ	
	N	%	N	%	N	%	N	%
1	35	13.8	31	12.2	5	2.0	5	2.0
2	16	8.2	20	10.2	1	0.5	2	1.0
3	11	8.6	10	7.9	2	1.6	3	2.4
totals	62	10.7	61	10.6	8	1.4	10	1.7
	ISTP		**ISFP**		**INFP**		**INTP**	
	N	%	N	%	N	%	N	%
1	12	4.7	19	7.5	9	3.5	7	2.8
2	16	8.1	19	9.6	11	5.6	7	3.6
3	8	6.3	5	4.0	7	5.6	5	4.0
totals	36	6.2	43	7.5	27	4.7	19	3.3
	ESTP		**ESFP**		**ENFP**		**ENTP**	
	N	%	N	%	N	%	N	%
1	27	10.6	17	6.7	12	4.7	8	3.1
2	15	7.6	17	8.6	13	6.6	9	4.6
3	7	5.6	10	7.9	18	14.3	7	5.6
totals	49	8.5	44	7.6	43	7.5	24	4.2
	ESTJ		**ESFJ**		**ENFJ**		**ENTJ**	
	N	%	N	%	N	%	N	%
1	29	11.4	23	9.1	7	2.8	8	3.1
2	23	11.8	13	6.6	7	3.6	6	3.0
3	12	9.4	13	10.3	3	2.4	7	5.6
totals	64	11.1	49	8.5	17	2.9	21	3.6

Chi Square = 34.1234

p = 0.2478

results.

Investigation of the relationship between age and MBTI type resulted in a Chi Square of 464.9609 with p = 0.0641.

Gender: The distribution of gender by course and achievement level failed to yield significant associations. Gender by course selection generated a Chi Square of 4.328 (p = 0.741) and gender by achievement level generated a Chi Square of 3.862 (p = 0.145). The appendix includes a table showing the distribution of gender for each course and each achievement level in the sample. Similarly, gender did not prove to be significantly associated with the NJTRS scores.

Assessment of the association between gender and type proved to be significant with Chi Square equal to 83.9377 (p < 0.001). Table 4.8 displays the distribution of MBTI type by gender. The distribution of gender and the dimensions of type also were investigated. Only a significant association between gender and the Thinking/Feeling dimension of type was found, Chi Square = 64.682, p < 0.001. Table 4.10 displays the distribution and summary of the results of the test of association.

A complete discussion of the implications of these findings can be found in Chapter Five.

Table 4.10

Distribution of Dimensions of Type

	N	%		N	%
1. Extraversion (E)	311	53.9%	Introversion (I)	266	46.1%
2. Sensing (S)	408	70.7%	Intuition (N)	169	29.3%
3. Thinking (T)	285	49.4%	Feeling (F)	292	50.6%
4. Judgment (J)	292	50.6%	Perception (P)	285	49.4%

Chi Square Goodness of Fit Test

Index	Chi Square	Probability
E/I	3.335	0.067
S/N	98.170	< 0.001
T/F	0.062	0.803
J/P	0.062	0.803

CHAPTER FIVE

Summary, Implications and Recommendations

This investigation attempted to determine the extent and nature of the relationship between students' MBTI preferences and their problem-solving skills. Specifically, three research questions were explored and seven hypotheses were tested. Additionally, based on the significant results, inquiry was made into the relationship of combinations of preferences to identified skill level. The research questions were:

1. Is there a relationship between the dimensions of type as measured on the MBTI and mathematical achievement level as indicated by placement in one of three mathematics course levels among community college students?
2. Is there a relationship between the dimensions of type measured on the MBTI and course level as indicated by placement criteria among community college students?
3. Is there a relationship between the dimensions of type as measured on the MBTI and problem-solving ability as indicated by total score on the New Jersey Test of Reasoning Skills?

The three research questions were designed to complement each other and to provide different avenues for examining the existence of connections between problem-solving ability and MBTI profiles. Achievement level provided a broad categorization of skill level. The students on each level possess a wide range of skills and capabilities. The breakdown by courses furnished a more homogeneous grouping of students as defined by the course hierarchy and a stringent prerequisite system. The scores from the NJTRS provided a metric measure of skills, rather than a grouping procedure. As indicated in Chapter Two, theory and previous research led to the belief that significant relationships exist.

The following hypotheses were designed to test relationships indicated in the literature descriptions of learning styles:

1. The indices of the MBTI interact significantly to predict achievement level.
2. The indices of the MBTI interact significantly to predict course level.
3. The indices of the MBTI interact significantly to predict problem-solving ability.
4. Students in developmental level courses demonstrate a stronger preference toward the introversion dimension of the extraversion/ introversion index than students in the higher level courses.

5. Students in developmental level courses demonstrate a stronger sensing preference on the sensing/intuition index than students in the higher level courses.
6. Students in developmental level courses demonstrate a stronger thinking preference on the thinking/feeling index than students in higher level courses.
7. Students in developmental level courses demonstrate a stronger preference in the judgment direction of the judgment/perception index than students in the higher level courses.

In addition to the research questions and hypotheses, the distribution of the combinations of the S/N and J/P indices in the sample along with the relationship between these combinations and achievement level were tested.

Chapter Five focuses on the study's significant findings and a discussion of their educational implications. Determination of some of the human factors relating to students' achievement level could lead to possible remedies for poor student retention and performance in mathematics. The chapter concludes with recommendations for further research.

Summary of Findings

Chapter Four contained numerous tables presenting the findings from tabulations, Chi Square tests, Correlations, and multiple regression techniques. Table 5.1 furnishes a summary of the significant findings for the research questions investigated and Table 5.2 summarizes the results for the hypotheses. The research questions provided a cross-validation of the investigation into the relationship of problem-solving skill level and the dimensions of type and the hypotheses tested for specific relationships.

The distribution of the Sensing Preference in the sample (70 percent of the sample) provided the first indication of significance. This result was consistent with Roberts′ (1975, pp. 5-6) findings that community college students are predominantly sensors (73.5 percent) and with similar results found by Myers (1980, pp. 32-33) for a cohort of high school students (71 percent). Examination of the results points out the significance of the Sensing/Intuition Index in predicting achievement level and a measure of problem-solving skills. Although this index was significant, it explains only 14.7 percent of the variance for achievement level and only 4.9 percent of the variance for the measure of problem-solving skills. A positive significant correlation of the S/N index with each of the measures of skill level suggests that students in

Table 5.1

Summary of Findings

Dependent Variable	Independent Variables	Findings
Achievement Level	Dimensions of Type	The S/N index had a significant relationship and accounted for 14.7% of the variance. While not significant at the 0.05 level, the J/P index contributed 13.2% to the variance.
Course	Dimensions of Type	The S/N and J/P indices both had significant relationships, accounting for 14.7% and 13.2% of the variance.
NJTRS	Achievement Level	Positive correlation: $r = 0.245$, $p < 0.00001$.
NJTRS	Course	Positive correlation: $r = 0.219$, $p < 0.00001$.
NJTRS	Dimensions of Type	The S/N and J/P indices were significant: S/N $r = 0.221$, $p < 0.001$ and J/P $r = 0.147$, $p < 0.001$.
NJTRS	Age	No significance demonstrated.
NJTRS	Gender	Spearman rho = -0.159, $p < 0.001$.

Table 5.2

Correlations

Independent Variables	Dependent Variables: Achievement Level	Dependent Variables: Course
E/I	No significance demonstrated	No significance demonstrated
S/N	rho = 0.117 $p < 0.01$	rho = 0.105 $p < 0.01$
T/F	No significance demonstrated	No significance demonstrated
J/P	No significance demonstrated rho = 0.061 $p = 0.074$	No significance demonstrated

Post Hoc Analysis:

Combinations of the S/N and J/P indices

Test	Findings
Test for Goodness of Fit Combinations ofthe Indices	Significant at $p < 0.001$
Test for Independence: Combinations by achievement level	Significant at $p < 0.01$

lower level mathematics courses had a stronger preference in the direction of the sensing dimension. Likewise, students in the college level courses demonstrated stronger preferences in the direction of the intuition dimension. Studying 9th grade students, Reynolds and Hope (1970) found similar results.

The proportion of the dimensions of the judgment/perception index in the sample was nearly equal: 50.6 percent preferred judgment and 49.4 percent preferred perception. Examination of the relationship of the actual scores to the measures of skill level furnished a clearer picture. The Judgment/Perception index was found to be a significant factor for skill level when measured by course and the NJTRS. The J/P index was not significant at the 0.05 level for the measure of achievement level even though that index contributed 13.2 percent to the variance. The positive correlation with the J/P index suggests that students in the lower level courses have a preference in the direction of the judgment dimension and students in the upper level courses have their preference in the direction of the perception dimension.

The relationships of the four combinations of the S/N and J/P were examined for Goodness of Fit and for independence when considered by level. The test for Goodness of Fit for the combinations of the S/N and J/P indices was significant at $p < 0.001$. The test for Independence of Proportions proved to be significant the 0.01 level. The significant findings of the S/N index in favor of the intuitive direction and the J/P index in favor of the perceptive direction are consistent with the results Novak and Voss (1981) found for eighth grade science students. Hengstler, Dennis and others (1981) also found a low to moderate relationship between achievement and the S/N index in favor of the N's as well as with the J/P index in favor of the P's.

No significant relationship between skills and the indices of extraversion/introversion and thinking/feeling were found. Although not significant, the direction of the relationship between achievement level, course, and NJTRS and the other indices of type should be noted. Correlation computations for each of these variables with the EI dimension as the predictor indicated a negative trend. This would seem to imply that the higher the skill level, the lower the introversion preference or students in the higher level skill categories demonstrate a stronger measure in the extraversion direction. This may be reflective of an increased development of confidence in these higher level students. This finding seems to be inconsistent with Reynolds and Hope (1970) who concluded that while not significant, introverted 9th grade science students score better on science achievement tests. Kramer's study of the possible relationships between MBTI type and expository and creative writing among college students also indicated that introverts tend to make higher grades (1977). The trend found in this study would seem to indicate the need for additional research regarding the E/I index for mathematics students on the community college level.

The relationship to the TF index was in the positive direction, implying a slightly higher preference in the direction of the feeling dimension for the more skilled students.

Implications and Recommendations for Classroom Instruction

The directions of the correlation tests for the variable indicating skill level seem to indicate that students demonstrating lower levels of skill favor the direction of the I, S, T and J preferences. When coupled with the literature search on the use of the MBTI as a construct for identifying learning styles, this awareness has implications for instructional techniques for mathematics. In particular, the following recommendations should be implemented or made to accommodate the strong sensing preference and the strong judgment preference indicated for the lower spectrum of the skill range:

1. As a part of the regular registration process, the students should take the MBTI and learning styles should be identified.
2. A highly detailed syllabus of the course and a

structured classroom environment should be provided for the highly sensing population with preferences in the direction of the judgment dimension.

3. Instruction on organizational and study skills should be included as a regular part of classroom instruction in the developmental and prealgebra level courses.
4. Applications should be presented before theory in the developmental classes.
5. Based on the intuitive preference for students in the higher level courses, theory should be presented before the applications.
6. Structure supported by factual or concrete examples which make the subject more practical should be provided in the lower level classes. Emley (1986) also provided support for this recommendation.
7. There should be a greater use of audiovisual materials and direct experience for the predominately sensing population.
8. Students should be exposed to a wide variety of techniques and approaches to problem-solving. The classroom should convey a problem-solving atmosphere and topics should be introduced and developed from this point of view. Students should be encouraged to integrate facts, formulas and techniques with

creativity and analysis, characterized by more discussion and open-ended applications.

9. Small group work and co-operative problem-solving should be encouraged.
10. Students should be motivated to invent their own problems and use a wide variety of techniques to solve them. A comparison of approaches will help the student to produce a synthesis of techniques. Consideration should be given to exposing students to a wide variety of authors or presentations rather than to the limitations of one text. Selecting exercises from at least two sources may help students to adapt to different problem-solving approaches.
11. Tests should contain more practical problems.
12. Math students should be taught to adapt to other learning styles. Hinkle (1986) also supported this recommendation.
13. Instructors should be made aware of their teaching style and be taught to adapt to the learning styles of their students when necessary. The attitude that a textbook, a chalkboard, and a piece of chalk are sufficient materials for effective classroom instruction should be reexamined carefully for the community college student.
14. In addition to changes in classroom instruction,

textbooks should be revised so that conceptual material is more practical. Textbooks should devote a large proportion of the material to problem-solving with realistic problems as a major focus. The presentation and approach should be varied in design and approach to accommodate students' varied learning styles. One of the ways to accomplish this would be to develop a companion text. This companion text should be written by authors who present the concepts in the same order as a standard text, but provide an alternative presentation or interpretation.

15. In addition to textbooks, materials should be used which appeal to all senses to reinforce learning. For example, auxiliary materials such as interactive computer videos should be available to provide opportunity for direct interaction.

Implications for Future Research

The significance of the S/N and J/P indices in this research suggest the need for changes in the delivery for the traditional mathematics course. The following recommendations are made for future research projects in order to contribute to and expand the knowledge base:

1. This study should be replicated at another community

college.

2. Problem-solving styles of students should be identified and compared to the indices of type.
3. The influence of the E/I and T/F indices should be explored in depth for the community college student.
4. Additional research should be conducted to determine effective strategies and materials.
5. Research should be conducted to test the effectiveness of a battery of mathematics teaching materials for groups of students who are strongly sensing.
6. Longitudinal studies should be conducted to ascertain relationships between possible shifts in MBTI preference scores and the development of mathematical problem-solving expertise.
7. Colleges should consider offering survival study skills during the first two weeks in the semester and then reinforce these throughout the semester. The research question: "Will learning survival study skills impact on preference scores and achievement?" should be examined.
8. Consideration should be given to making developmental students aware of their profile type and its advantages and disadvantages in relation to achievement in mathematics. Would students then work consciously to develop strengths in weaker

preferences if these were needed for achievement or would they only take courses with their preferred "type" teacher?

9. Similarly, instructors could be made aware of their preference and its impact on the teaching strategies they use. Can instructors also work consciously to develop strengths in their weaker preference so they may accommodate students preferring different instructional styles?
10. Research should be undertaken to determine if the same relationships exist for students at four-year colleges or universities.
11. The community college curriculum includes a variety of technical training programs. Similar groups may be found in non-collegiate settings such as company-sponsored training programs. Trainees in these on-the-job training programs should be studied and the influence of type preferences determined. Then, instructional delivery systems in these programs should be examined for congruency of teaching and learning styles.

Concluding Comments

This investigation has only scratched the surface in the determination of factors contributing to the development of successful problem-solving. Evidence of the relationship between the S/N and J/P preferences and problem-solving skill level has underscored the need for further investigation. The role of the J/P index should be explored further for the community college cohort. In particular, the relationships of preference and instructional design should be investigated further to determine delivery systems which will serve fully the variety of learning styles which exist in the same classroom setting.

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APPENDIX A

Distribution of Ages by Achievement Level

APPENDIX A

Distribution of Ages by Achievement Level

Age	Achievement Levels 1 N	1 %	2 N	2 %	3 N	3 %	Totals N	Totals %
16	1	0.4	0	0.0	0	0.0	1	0.2
17	2	0.8	4	2.1	3	2.3	9	1.6
18	79	31.1	60	30.8	14	10.9	153	26.5
19	48	18.9	48	24.6	19	14.8	115	19.9
20	24	9.4	25	12.8	25	19.5	74	12.8
21	17	6.7	11	5.6	12	9.4	40	6.9
22	17	6.7	6	3.1	13	10.2	36	6.2
23	11	4.3	6	3.1	4	3.1	21	3.6
24	5	2.0	4	2.1	6	4.7	15	2.6
25	4	1.6	4	2.1	4	3.1	12	2.1
26	9	3.5	3	1.5	5	3.9	17	2.9
27	5	2.0	2	1.0	3	2.3	10	1.7
28	6	2.4	1	0.5	3	2.3	10	1.7
29	3	1.2	1	0.5	0	0.0	4	0.7
30	4	1.6	2	1.0	2	1.6	8	1.4
31	6	2.4	3	1.5	2	1.6	11	1.9
32	0	0.0	1	0.5	1	0.8	2	0.3
33	1	0.4	1	0.5	0	0.0	2	0.3
34	4	1.6	2	1.0	0	0.0	6	1.0
35	1	0.4	1	0.5	3	2.3	5	0.9
36	4	1.6	0	0.0	2	1.6	6	1.0
37	0	0.0	1	0.5	1	0.8	2	0.3
38	0	0.0	0	0.0	2	1.6	2	0.3
39	2	0.8	3	1.5	1	0.8	6	1.0
40	0	0.0	4	2.1	1	0.8	5	0.9
41	0	0.0	1	0.5	1	0.8	2	0.3
42	0	0.0	0	0.0	0	0.0	0	0.0
43	0	0.0	0	0.0	0	0.0	0	0.0
44	0	0.0	0	0.0	1	0.8	1	0.2
45	0	0.0	0	0.0	0	0.0	0	0.0
46	0	0.0	1	0.5	0	0.0	1	0.2
47	0	0.0	0	0.0	0	0.0	0	0.0
48	1	0.4	0	0.0	0	0.0	1	0.2

Chi Square = 84.0815
$p = 0.0090$

Chi Square for Age by Course: 248.1978
$p = 0.0069$

APPENDIX B

Distribution of Ages by Gender

APPENDIX B

Distribution of Ages by Gender

Age	Gender				Totals	
	Females		Males			
	N	%	N	%	N	%
16	1	0.2	0	0.0	1	0.2
17	5	0.9	4	0.7	9	1.6
18	85	14.7	68	11.8	153	26.5
19	55	9.5	60	10.4	115	19.9
20	34	5.9	40	6.9	74	12.8
21	22	3.8	18	3.1	40	6.9
22	15	2.6	21	3.6	36	6.2
23	11	1.9	10	1.7	21	3.6
24	11	1.9	4	0.7	15	2.6
25	6	1.0	6	1.0	12	2.1
26	7	1.2	10	1.7	17	2.9
27	6	1.0	4	0.7	10	1.7
28	4	0.7	6	1.0	10	1.7
29	4	0.7	0	0.0	4	0.7
30	4	0.7	4	0.7	8	1.4
31	10	1.7	1	0.2	11	1.9
32	2	0.3	0	0.0	2	0.3
33	2	0.3	0	0.0	2	0.3
34	5	0.9	1	0.2	6	1.0
35	4	0.7	1	0.2	5	0.9
36	6	1.0	0	0.0	6	1.0
37	2	0.3	0	0.0	2	0.3
38	1	0.2	1	0.2	2	0.3
39	5	0.9	1	0.2	6	1.0
40	5	0.9	0	0.0	5	0.9
41	1	0.2	1	0.2	2	0.3
42	0	0.0	0	0.0	0	0.0
43	0	0.0	0	0.0	0	0.0
44	0	0.0	1	0.2	1	0.2
45	0	0.0	0	0.0	0	0.0
46	1	0.2	0	0.0	1	0.2
47	0	0.0	0	0.0	0	0.0
48	1	0.2	0	0.0	1	0.2
Total	315	54.6	262	45.4	577	100.0

Chi Square = 43.7453
p = 0.0294

APPENDIX C

Distribution of Gender by Course Enrollment

APPENDIX C

Distribution of Gender by Course Enrollment

	Gender					
	Females		Males		Total %	
Level and Course	N	%	N	%	N	%
Developmental:						
1	65	20.6	49	18.7		
2	83	26.3	57	21.8		
Totals	148	47.0	106	40.5	254	44.0%
Prealgebra:						
3	63	20.0	53	20.2		
4	44	14.0	37	14.1		
Totals	107	34.0	90	34.4	197	34.1%
College Level:						
5	7	2.2	8	3.1		
6	27	10.3	28	10.7		
7	13	4.1	17	6.5		
8	13	4.1	13	5.0		
Totals	60	19.0	66	25.2	126	21.8%

Gender by Course: Chi Square = 4.328 $p = 0.741$

Gender by Skill Level: Chi Square = 3.862 $p = 0.145$

APPENDIX D

Distribution of Gender and Dimensions of Type

APPENDIX D

Distribution of Gender and Dimensions of Type

Extraversion (E)

	N	%
females	170	54.0
males	141	53.8
totals	311	53.9

Introversion (I)

	N	%
females	145	46.0
males	121	46.2
totals	266	46.1

Sensing (S)

	N	%
females	221	70.2
males	187	71.4
totals	408	70.7

Intuition (N)

	N	%
females	94	29.8
males	75	28.6
totals	169	29.3

Thinking (T)

	N	%
females	107	34.0
males	178	67.9
totals	285	49.4

Feeling (F)

	N	%
females	208	66.0
males	84	32.1
totals	292	50.6

Judgment (J)

	N	%
females	161	51.1
males	131	50.0
totals	292	50.6

Perception (P)

	N	%
females	154	48.9
males	131	50.0
totals	285	49.4

Chi Square = 66.208

$p < 0.001$

Test of Association for Each Index

Index	Chi Square	Probability
E/I	0.002	0.962
S/N	0.052	0.820
T/F	64.682	< 0.001
J/P	0.033	0.855

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AN INVESTIGATION OF THE RELATIONSHIPS BETWEEN THE FOUR TYPOLOGICAL DIMENSIONS OF THE MYERS-BRIGGS TYPE INDICATOR AND PROBLEM-SOLVING SKILL LEVEL IN MATHEMATICS AT THE COMMUNITY COLLEGE

by

Julia Ann Brown

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(ABSTRACT)

This exploratory study investigated the relationships between community college students' Myers-Briggs typology preferences and their problem-solving skills. The literature provides reason to believe that students' MBTI preferences are related to problem-solving style and ability. The educator's ability to teach problem-solving will be enhanced through an identification of motivational patterns affecting learning.

A sample of 577 community college students participated in the study. Achievement Level for each student was identified using the New Jersey College Basic Skills Placement Test. In addition, problem-solving ability was measured using the New Jersey Test of Reasoning Skills. The Myers-Briggs Type Indicator, Form F, provided the MBTI profile scores.

Chi Square analyses, correlations, and stepwise regression techniques were employed to identify and test relationships. The best identified predictor was the student's preference on the Sensing/Intuition index. Preference on the Judgment/Perception index also proved to be significant. Students who have the least skills in mathematics problem-solving have stronger preferences in the direction of the sensing dimension and the judgment dimension.

Implications and recomendations for classroom instruction were presented and recommendations for related research were suggested.