THE RELATIONSHIPS BETWEEN PROBLEM SOLVING STYLE AS MEASURED BY THE MYERS BRIGGS TYPE INDICATOR AND ACHIEVEMENT IN COLLEGE CHEMISTRY AT THE COMMUNITY COLLEGE

by

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Introduction

College Chemistry is a science subject in which many students experience failure. Several educational researchers have voiced their concern for this failure (Coley,1973; Hunter, 1976; Paul,1978). Schools respond in a variety of ways to this problem. In one case (Paul, 1978), where 40% of the enrolled students failed freshman chemistry by earning a "D" or lower grade, the chemistry requirement was abolished for pre-nursing students. Such drastic measures are not the normal approach to solving the problem. The typical response is to devise screening methods that limit access to the college chemistry course to those students most likely to pass it. (Coley,1973). The screening methods employed are usually based on the results of studies on academic achievement.

Tools used for the prediction of achievement in college chemistry have shown varying degrees of success. Coley (1973) found that a preparatory chemistry course was the best predictor of success in the college chemistry course. This accounted for 18 % of the variance. For those students who did not take the preparatory course, the Toledo Chemistry Placement Examination (TCPE) was found to be the best predictor of success. It explained 15 percent of the variance. Paul (1978) found that although there was a relationship between American College Testing

(ACT) scores and performance in freshman chemistry, other factors such as major field of study seem to influence student performance in freshman chemistry. For example, pre-nursing students whose composite ACT score was 20.69 outperformed, by 0.2 grade points, non-nursing students whose compositeACT score was 21.30. Hunter (1976) reported that Toledo Chemistry Placement Examination scores had been used at Western Kentucky University to predict success in college chemistry. A score above 40 on the TCPE was said to indicate a 75 percent chance of earning a "C" or better grade in college chemistry. A score less than 40 was said to indicate a 67 percent chance of failing college chemistry with a "D" or "F" grade. These predictions were supported by the final grades obtained by students.

Chemistry 111 at Northern Virginia Community College

Only about 56% of the approximately 200 students who enroll in College Chemistry 1 (Chemistry 111) each quarter at Northern Virginia Community College, Annandale Campus (NVCC AN) successfully complete the course. Chemistry 111 is the first quarter of college level chemistry. Successful completion is defined as obtaining a "C" or better grade because only such grades are college transferrable. About 25% of the students enrolled withdraw from College Chemistry 1 before the end of the sixth week

of classes.

Since about 1978, efforts have been under way in the Chemistry Department at NVCC AN to screen students wishing to enroll in Chemistry 111. The results of these efforts have led to the use, in 1982, of a locally modified version of the Toledo Chemistry Placement Examination as a screening test. Prior to this recent use of a screening test, Toledo test scores were used to advise students in regard to enrollment in Chemistry 111.This screening test is called the Pretest. After the implementation of the Pretest, an increase of 4 to 6% was seen in the percentage of students passing College Chemistry 1 with a "C" or better grade.

The Pretest is primarily a test of mathematic ability. The grades obtained on the first four chapter tests in a Chemistry 111 class held during the Fall quarter 1982 were examined. It was found that the percent of students earning a "C" or better grade was 95% for chapter 1, 90% for chapter 2, 60% for chapter 3, and 25% for chapter 4. This averages to 67% passing the course by the completion of chapter 4. The first chapter of the Chemistry 111 textbook deals primarily with mathematics. The second chapter requires memorization. The third chapter requires the use of analytical skill coupled with mathematical skill. The fourth chapter requires the understanding of chemical reactions, and an increased

usage of analytical skill along with mathematical calculations. The grades appeared to decline as the need for analytical skill increased.A further look was taken at the requirements for earning a "C" or better grade in college chemistry. Students are required to take tests on individual chapters as well as a comprehensive final examination. Since the final examination is comprehensive, an item analysis based on Bloom's Taxonomy of Educational Objectives (1956) was performed on final examination questions. These results indicate that the most important ability for achievement in college chemistry is the ability to perform analysis. Sixty seven point five percent of the questions on the final examinations for Chemistry 111 fall in the category of analysis. The next most important category is application. The ability to apply concepts, theory, and knowledge is required for 27.5% of the questions. Analysis is a method of problem solving. An example of the type of problem solving categorized as analysis in College Chemistry 1 is shown in Appendix A. The academic concern voiced so far is a major part of the problem, but other factors contribute to the seriousness of the problem. The low passing rate for college chemistry at NVCC AN points to inefficient use of the available human and physical resources. There is a limit to the number of students who can enroll in college chemistry each quarter. This limit is due in part to the

fact that the laboratory used for college chemistry courses can hold only 20 students at a time. Each laboratory period is 3 hours long, so there is a physical limit to the number of students who can be accommodated. Another limitation is the recent budget restraints which make it difficult, if not impossible to hire new full-time faculty. Further inefficiency occurs due to enrollment procedures. Some students who enroll in college chemistry withdraw from the course before the census date. This withdrawal is not documented. There is, however, a documented 25% withdrawal of students after the census date. Although students can withdraw after the census date, no students can enroll at this time, so students who were qualified to enroll in the course but were prevented from doing so because the course was full cannot enroll when spaces become available after the census date. The students who withdraw from the course usually do so because they are failing. A more effective screening mechanism would alleviate this inefficient use of human and physical resources in college chemistry.

The Problem

There needs to be a better method of predicting success incollege chemistry. The current screening test predominantly assesses mathematic ability which is only part of the required academic skill for success in

college chemistry. An additional screening method that would broaden the scope of the current method to include other necessary skills should provide a more accurate predictive tool.

Part of the difficulty in accurately predicting achievement in science may be that more than one variable is related to such achievement. Thorsland and Novak (1974) have shown that both intuitive and analytical approaches are necessary to success in college physics. They based their learning model on Ausubel's (1968) theory of learning which looks at cognitive structure as consisting of a series of hierarchical concepts or subsumers. The analytic dimension of problem solving behavior was said to begin problem solving at the subordinate concepts and move up to the superordinate concepts. This was considered to be a step-by-step approach to problem solving. The intuitive dimension of problem solving was said to begin problem solving with superordinate ideas and higher level subsumers, and to make several referrals to subordinate concepts as necessary. These "analytic" and "intuitive" dimensions defined by Thorsland and Novak are very much like the "thinking"(T) and "intuitive " (N) types defined by Myers (1982). According to Myers, thinking types "like analysis and putting things into logical order", while intuitive types "put two and two together quickly, and are patient with complicated

situations". Myers' intuitive thinking (NT) types epitomize the combination of Thorsland and Novak's intuitive and analytic dimensions. The exact opposite of the NT types is the SF (sensing feeling) type. Myers, 1982. It should follow then, that NT students should do better on analysis type problems than SF students. The results of psychological studies such as those performed by McCaulley (1977), Novak and Voss (1981), and Hengstler and others (1981), show that there is reason to believe that problem solving style as measuredby the Myers-Briggs Type Indicator (MBTI) plays an important part in predicting achievement in college chemistry. McCaulley found that there was a predominance of intuitive thinking type students in the physicai sciences and engineering, while sensing-thinking types predominated in biological sciences. Novak and Voss found differences in performance on standard tests of intelligence between sensing and intuitive type students, and between judging and perceiving type students. The intuitives and perceivers were found to perform better on these tests than their counterparts. Hengstler and others found that at a predominantly female college campus, intuitive type students obtained higher first year grade point averages than sensing type students. In spite of inconsistencies found in other portions of their study, these researchers suggest that "the MBTI has the potential for being an

important predictor of academic success for select groups." (Hengstler, and others, 1981).

According to the directions on the cover of the Myers-Briggs Type Indicator, one's answers to the questions on the Indicator "will help show how you like to look at things and how you like to go about deciding things." For the purposes of this study, MBTI types will be considered to be problem solving styles.

Statement of Purpose

The purpose of this study is to investigate the relationships that might exist between achievement in college chemistry and problem solving style as measured by the MBTI. To this end, the following research questions and hypotheses are posed:

Research Questions

1. Is there a relationship between problem solving style as measured by the MBTI and achievement in College Chemistry 1?

2. Does problem solving style based on MBTI type add to the variance explained by the Pretest?

3. Is there a difference in the distribution of grades assigned by different instructors in College Chemistry 1?

4. Is there a difference in grade distribution

according to MBTI profile?

5. Is there a difference in problem solving style as measured by the MBTI for students who pass College Chemistry 1 with a "C" or better grade,those who fail College Chemistry 1 witha "D" or "F" grade, and those who withdraw from the course?

6. Is there a difference in distribution of final exam scores by problem solving style as measured by the MBTI?

7. Is there a relationship between problem solving style as measured by the MBTI and final exam score?

Hypotheses

Based on the discussion in this chapter of Thorsland and Novak's (1974) "intuitive" and "analytic" approaches, and Myers' (1982) "intuitive" and "thinking" types, the following hypotheses are offered for this study.

1. Students whose MBTI profiles include both the N and T dimensions will achieve higher grades in College Chemistry 1 than students whose profiles include both the S and the F dimensions.

2. Students whose profiles contain the N dimension combined with any three of the other possible dimensions will achieve better grades in College Chemistry 1 than students whose profiles include the S dimension combined with any three of the other possible dimensions.

3. Students whose profile contain the T dimension in combination with any three of the other possible dimensions will achieve better grades in College Chemistry 1 than students whose profiles contain the F dimension in combination with any three of the other possible dimensions.

Definitions of Terms

Problem solving style:- Problem solving style is described by any one of the sixteen characteristic ways of receiving, processing, and utilizing information that is measured by the MBTI.

Achievement in college chemistry:- Is defined as obtaining any of the grades A, B, C, D, F, or W in College Chemistry 1.

Passing college chemistry:- This is the ability to earn a "C" or better grade in College Chemistry 1.

College Chemistry 1:- College Chemistry 1 is the same as Chemistry 111. It is the first college level inorganic chemistry course for science and engineering majors.

Limitations of the Study

The research sample consists of students enrolled in Chemistry 111 during the Fall and Winter quarters, 1983. The study is limited by the extent to which these students

are typical of Chemistry 111 students. The study is being conducted at the Annandale campus and may be limited to students whose demography matches that typified by students at this suburban campus.

The accuracy of the problem solving style variable is limited by the ability of the MBTI to sort this, and by the veracity with which the students completed the questionnaire.

Significance of the Study

The results of this study could lead to the development of an additional screening method for Chemistry 111 that would improve on the predictive quality of the currently used Pretest. In addition to this, some insight should be gained about students' problem solving styles, and the relationships these might have to success in College Chemistry 1. Such information could assist in the development of instructional techniques that would be useful in teaching College Chemistry to students with a variety of problem solving styles.

Summary of Chapters

Chapter one contains the introduction to this research project. It explains a problem that exists in the College Chemistry 1 course at NVCC AN. The purpose of the study is stated. Research questions and hypotheses concerning the

relationship between problem solving style as measured by the MBTI and achievement in College Chemistry 1 are put forward. Terms to be used in the research are defined. Limitations of the study are noted and the significance of the study is suggested. Finally, there is a summary of each chapter in this dissertation.

A review of the pertinent literature is contained in Chapter Two. Synopses of writings on the MBTI as it relates to school achievement in general, and achievement in science in particular are made. Detailed descriptions of problem solving styles as defined by the MBTI are presented. The general behaviors and scholastic preferences typified by each MBTI type are examined.

Chapter Three deals with the research methodology. In it, the research question, research design, and a brief description of the research instruments are listed. The available population, the sample used, and the data collection procedures are described.

The results of the statistical procedures used on the data are presented in Chapter Four. The relationships between various MBTI preferences and achievement in College Chemistry 1 are quantified. The variance explained by the Pretest alone, and by the Pretest in combination with various MBTI dimensions is evaluated. The possibility of instructor influence on grades is evaluated. A search is made for grade distribution

differences according to MBTI profile. Characteristic problem solving style as determined by the MBTI is identified for students who earn a "C" or better grade, for those who earn "D" or "F" grades, and for those who withdraw from the course. Differences between problem solving style as measured by the MBTI and the distribution of final exam scores are examined. Relationships between problem solving style as measured by the MBTI and final exam score are investigated.

A discussion of the results of the statistical evaluations with ensuing conclusions and recommendations are containedin Chapter Five. The inferences that could be drawn from the results of this study are discussed at length. The extent to which the research questions have been answered is examined. Recommendations as to what action could be taken, based on the results of this study are put forward.

Chapter2

Review of the Literature

Chapter Organization

Chapter 2 is organized as follows. A precis of studies on achievement in college science and problem solving style in college science is presented. The concept of personality type as measured by the MBTI is explained in detail. For the purpose of this study, personality type as measured by the MBTI is considered to be problem solving style. The eight dimensions of the MBTI are described individually and in successive combinations. Some relationships between personality type and occupation are presented. The literature on learning styles and academic performance as related to the MBTI is discussed. Academic performance in various scientific fields is included. The chapter concludes with a summary of the relationships between the MBTI and academic performance as presented in the literature.

Achievement in College Science

Coley (1973) was concerned about the failure rate in college chemistry at Chabot College in Hayward, California. This failure rate was attributed to lack of preparation by students. Both a screening test and a preparatory chemistry course were introduced in an effort to reduce the failure rate. It was found that students who scored

above 50 on the Toledo Chemistry Placement Examination, as well as students who took the preparatory chemistry course had a high probability of passing college chemistry. A reduction of the failure rate in college chemistry ensued after introduction of these two measures.

Hunter (1976) found that a preparatory chemistry course was a good way to salvage underprepared college chemistry students. His study showed that students who scored below 40 on the Toledo Chemistry Placement Examination did poorly in college chemistry; but when those same students took a preparatory chemistry course, their chances of passing college chemistry increased significantly.

Paul (1978) found that American College Testing (ACT) scores, as well as major field of study had a relationship to performance in college chemistry. Science majors with high ACT scores earned higher grades in college chemistry than nonscience majors with similar ACT scores.

Thorsland and Novak (1981) found that both intuitive and analytic approaches were important to problem solving in college physics. The 70 physics students in their study used both approaches in solving physics problems. Some students relied more heavily on one approach than another, while some students appeared to use both approaches relatively equally. The intuitive approach was characterized by an implicit understanding of the subject

matter with "no conscious awareness of the steps used in arriving at an answer." The analytic approach was considered to be "a step-by-step analysis of the problem." These explanations are simplifications of Ausubel's subsumer theory from which Thorsland and Novak borrowed.

Description of the MBTI

The Myers-Briggs Type Indicator,(MBTI), is a paper and pencil self-inventory which can be completed in about an hour and can be scored in just a few minutes. It has been determined to be a valid and reliable tool for identifying an individual's personality type (Carlyn,1977; Cohen,Cohen, & Cross, 1981). Carlyn (1977) found that the SN and JP scales of the MBTI consistently correlate with each other. MBTI profile has been found to have a definite bearing on choice of college major and on school achievement. (Deines,1974; Stone,1978; Hengstler et al, 1981). An in depth look at the recent literature in the field will explain the concepts applied and the applications made in educational research utilizing the MBTI.

The MBTI is not a new inventory, it was developed in the 1940's by Isabel Briggs Myers. It has been refined over the years, and has been used extensively in educational research. Before sensible use can be made of the MBTI, one must understand exactly what it measures. A good explanation of the traits measured by the MBTI can be

found in Gifts Differing by Isabel Briggs Myers (1980),in which she thoroughly explains personality differences in terms of personality development, learning preferences, academic and career choices, inter-personal relationships, and the individual's approach to the world around him, and to himself.

According to Myers, personality differences lie in the different ways of perceiving and judging. Perceiving and judging make up a large portion of an individual's mental processing. Perception is defined as that which the individual receives as input into his brain, and judgement is defined as that which the individual outputs in return.

There are two ways of perceiving. These occur as sensing or intuition. Individuals are capable of perceiving by using either sensing or intuition, but never both at the same time. And, indeed, individuals demonstrate a predilection for one or the other mode of perceiving. Perception through sensing requires the use of the five senses; smell, taste, touch, sight, and hearing. Perception through intuition entails the unconscious incorporation of ideas and their interrelations.

Similarly, there are two ways of judging. These two ways are termed thinking and feeling. Thinking judgement is impersonal and looks for logic and consistency. Feeling judgement is involved with emotional comfort and other people's feelings. As with perceiving, individuals

can judge by applying thinking or feeling but never both at the same time; and, indeed, individuals have a preferred way of judging.

An individual's preferred way of perceiving and his preferred way of judging are the modes of mental processing that he feels most comfortable with, and uses most often. This preferential usage begins early in childhood and through repetition the preferences are strengthened. The auxiliary modes are suppressed. Four possible combinations result from these two ways of judging and of perceiving. They are,

ST (Sensing and Thinking)

SF (Sensing and Feeling)

NF (Intuition and Feeling)

NT (Intuition and Thinking)

Another facet of personality types is the way in which people relate to the world. They can do this in terms of the world around them; that is,in an extroverted (E) manner; or they can do this in terms of their inner selves, that is, in an introverted (I) way. This is the EI preference. The extrovert is interested in people and things. The introvert is interested in concepts and ideas. Although individuals use introversion at times and extroversion at other times, each individual has a definite

preference for one or the other.

This third preference, when combined with the sensing/intuition preference, and the thinking/feeling preference allows eight possible different combinations,

EST	IST
ESF	ISF
ENF	INF
ENT	INT

The above eight possible personality types are the ones that were first postulated by Carl Jung (Myers,1980). Myers has added a fourth dimension, the judgement/perception, (JP), preference. This preference defines the attitude an individual uses in dealing with the world around him. 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. People use both judging and perceiving in their lives, but each individual tends to prefer using one more than the other. Thus individual preference in regard to judging or perceiving is established through repetitive, reinforcing use. This fourth category, JP, the judgement/perception category, makes sixteen different combinations possible in the Myers-Briggs typology. The sixteen possible

combinations are,

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

Each human being, regardless of his nationality, has a personality type which can be defined by one of the sixteen possible sets of four traits. The TF scale is the only one that shows a definite correlation to sex. Each personality type has a dominant trait that can be found in either the SN or TF preference. These dominant traits have been identified by Myers (1980) as follows:-

S is dominant for ISTJ, ISFJ, ESTP, and ESFP.
N is dominant for INFJ, INTJ, ENFP, and ENTP.
T is dominant for ISTP, INTP, ESTJ, and ENTJ.
F is dominant for ISFP, INFP, ESFP, and ENFJ.

Personality type is said to be inborn. Environment is thought to either help or hinder consummate type development.

Choice of occupation is one of the life-choices that is influenced by personality type. The relationship between occupation and type has been scrutinized and a

synopsis of this relationship is presented in Gifts Differing (Myers, 1980) and is reproduced below.

	ST(%)	SF(%)	NF(%)	NT(%)
OCCUPATIONS				
Accountants	64	23	4	9
Bank employees	47	24	11	18
Sales, customer relations	11	81	8	0
Creative writers	12	0	65	23
Research scientists	0	0	23	77

This relationship between personality type and occupation is reputed to transcend language and cultural differences.

MBTI Based Learning Styles

Learning styles also are influenced by personality type. For example, intuitive people, N's, learn well in lecture type situations because they can rapidly convert words and symbols into meaning. Sensing people are slower at decoding words and learn better in a hands-on situation. (Myers, 1980).

Keirsey and Bates (1978) utilized the MBTI and have written concise descriptions of four learning styles in Please Understand Me: Character and Temperament Types. The four styles chosen were SP, SJ, NT, and NF. The SP

individual needs to be physically involved with his learning: He needs hands-on experience, competition, an opportunity to perform, and a chance at risk taking. This fun loving individual enjoys working as part of a team. He dislikes routine, and needs a frequent change of pace. He is egalitarian and dislikes being bossed. For this reason, he rebels against teachers. He enjoys verbal and visual presentations but abhors the traditional lecture, Socratic questioning, homework, and workbook assignments. He needs spontaneity, change, and excitement. He is attracted to active endeavors such as music, drama, art, crafts, mechanics, and construction.

The SJ learner needs to belong to the group with which he is associated, whether it be a family group or a classroom group. He conforms to the standards set forth by the authority figure and is usually obedient to the teacher. He needs a consistent, stable teacher. He learns well from the traditional approaches to teaching such as the lecture, and lecture-demonstration methods. He is a responsible individual who takes school assignments seriously. He has good study habits and is conscientious. He needs structured lessons presented in sequential, logical increments. He needs clear directions and time to prepare for the task at hand. He is not good at "winging it", nor is he good at long-term, independent projects. He enjoys clerical and business classes.

The NT person wants to know everything. He is an independent learner, capable of pursuing information on his own until his quest for knowledge is at least temporarily satisfied. He gathers rules and principles, and needs to give structure to his cognitive world. His intellectual curiosity focuses on technology. He is interested in mathematics and science. He has a tendency to push himself just beyond comfortable limits. If he has mastered something he may escalate his standards. The NT is an intellectual snob, but likes to share his ideas with those whom he considers his intellectual peers. His social skills are not well developed and he is not moved by emotional displays. He learns easily from logical, didactic presentations, but may need help setting priorities because he is not easily convinced that he cannot learn everything.

The NF learner has a burning need to determine who he is. It is important to him that a teacher knows him by name and acknowledges him as a person. He works well in a small group, but can work independently for a time. He learns from the discussion method, role playing, dramatic play, and through fiction. He enjoys reading and has a large spoken vocabulary. He requires constant positive feedback. He prefers subjects that deal with people over abstract subjects and tends to major in the liberal arts.

Gordon Lawrence's <u>People Types and Tiger Stripes</u>

(1979), was designed to help teachers understand how pedagogical approaches need to vary to meet the learning styleneeds of students withdifferent personality traits. The personality traits of the teachers are shown to play an important part in teaching-learning interactions. Lawrence applies the MBTI and approaches learning from the trait constituents of motivation. According to Lawrence, motivation can be broken down into four parts corresponding to the four dimensions of type. The first part concerns the extroversion/introversion dimension. This dimension indicates whether the learner is naturally interested in the world around him or the world of ideas within himself. The second part deals with the sensing/intuition preference which indicates basic differences in learning style. The third part,the thinking/feeling dimension, sheds light on the learner's values and committments. Finally, the learner's work habits can be related to the judging/perceiving dimension. The salient characteristics of these four parts, including the auxiliary parts have been excerpted from Lawrence (1979) and reproduced below.

Extrovert	Introvert
Likes to work with others and with one with large groups.	Likes to work alone or with one person.

Readily talks over events and ideas with others.

Wants to experience things so as to understand them.

Has a short attention span.

Often acts before thinking.

Prefers written to oral presentations.

Asks questions to allow understanding before doing something.

Has a long attention span.

Thinks before acting.

Sensing

Intensely aware of the environment.

More observant than imaginative.

Likes an established routine.

Works steadily to a conclusion.

Pays attention to details.

Dislikes new problems unless there are standard ways to solve them.

Brings up pertinent

Intuition

Aware only of personally relevant parts of the environment

More imaginative than observant.

Dislikes routines.

Jumps to conclusions.

Looks at the whole concept. rather than at details.

Likes spotting problems and solving them.

Looks far ahead,

facts.

furnishes new ideas.

Thinking	Feeling
Is logical and analytical.	Permits feelings to override logic.
Impersonal and impartial.	Personal and guided by emotion.
More truthful than tactful.	More tactful than truthful.
Does not need harmony.	Needs harmony.
Is concerned about facts, theories, and the discovery of truth.	Is concerned about emotional relationships and ideals.

Judging	Perception
More decisive than curious.	More curious than decisive.
Lives according to plans.	Lives according to the situation of the moment.
Is self-regimented, purposeful and exacting.	Is flexible, adaptable and tolerant.
Has settled opinions.	Is open-minded.
Is tolerant of routines.	Intolerant of routines.

Major Traits of the Sixteen MBTI Types

Each individual can be typed according to his dominant

trait in each of the four dimensions, EI,SN, TF, AND JP. the sixteen personality types (data processing styles) that arise from the possible combinations of the four dimensions are succinctly described in the Introduction to Type by Isabel Briggs Myers which is appended to Lawrence's People Types and Tiger Stripes. The following is a synopsis of Briggs Myers' description of the sixteen types.

The ISTJ person is serious, quiet, and earns success by concentration and thoroughness. He takes responsibility; is practical, orderly, matter-of-fact, logical, realistic, and dependable. He personally decides what should be accomplished and works steadily towards that goal regardless of protests and distractions.

The ISTP individual is a cool onlooker. He is quiet and reserved, observing and analyzing life with detached curiosity and unexpected flashes of original humor. He exerts himself no more than he thinks necessary because any waste of energy would be inefficient. He is usually interested in impersonal principles, cause and effect, or how and why mechanical things work.

The ISFJ person works devotedly to meet his obligations and serve his friends and school. He is thorough, painstaking and accurate. He is patient with detail and routine but may need time to master technical subjects as his interests are not often technical.

The ISFP person is retiring, quietly friendly, sensitive, and modest about his abilities. He shuns disagreements, and does not force his opinions or values on others. He usually does not care to lead but can be a loyal follower. He may be rather relaxed about assignments or getting things done because he enjoys the present moment and does not want to spoil it by undue haste or exertion.

The ESTP individual is matter-of-fact, does not worry or hurry, and enjoys whatever comes along. He tends to like mechanical things and sports with friends on the side. He may be a bit blunt and insensitive. He can do math and science when he sees the need. He dislikes long explanations. He does best at real things that can be handled, taken apart or put back together again.

The ESTJ person is a matter-of-fact, practical realist with a natural head for business or mechanics. He is not interested in subjects he sees no use for but can apply himself when necessary. He likes to organize and run activities, and does this well especially when he remembers to consider other people's feelings when making decisions.

The ESFP individual is an outgoing, friendly, easygoing person who is fond of a good time. He enjoys sports. He likes to make things. He finds it easier to remember facts than to master theories. He lives his outer life with sensing and his inner life with feeling.

The ESFJ is a warm-hearted, talkative, popular, conscientious person who is a born cooperator, and active committee member. He is always doing something nice for someone. He works best with plenty of encouragement and praise. He has little interest in abstract thinking or technical subjects. His main interest is in things that directly and visibly affect people's lives.

The INFJ person succeeds by perseverence, originality and desire to do whatever is needed or wanted. He puts his best efforts into his work. He is quietly forceful, conscientious. and concerned for others.

The INFP person cares about learning, ideas, language, and independent projects of his own. He tends to undertake too much, then somehow gets it done. He is friendly, but is often too absorbed in what he is doing to be sociable or to notice much.

The INTJ individual uses his original mind and great drive for his own purposes only. He is competent and self-sufficient in fields that appeal to him. He is skeptical, critical, independent, determined, and often stubborn.

The INTP individual is quiet , reserved, and brilliant in exams , especially in theoretical or scientific subjects. He is logical to the point of hair-splitting. He is interested mainly in ideas, with little liking for parties or small talk. He tends to have very sharply

defined interests.

The ENFP person is warmly enthusiastic, high-spirited, ingenious, and imaginative. He is able to do almost anything that interests him. He is quick with a solution for any difficulty and ready to help anyone with a problem. He often relies on his ability to improvise rather than preparing in advance. He can always find compelling reasons for whatever he wants.

The ENFJ person is responsive and responsible. He feels real concern for what others think and want, and tries to handle things with due regard for other people's feelings. He can present a proposal, or lead a group discussion with ease and tact. He is sociable, popular, active in school affairs, but allows enough time for his studies so as to do good work.

The ENTP individual is quick, ingenious, and good at many things. He is alert and outspoken, is stimulating company, and argues for fun on either side of the question. He is resourceful in solving new and challenging problems, but may neglect routine assignments. He turns to one new interest after another, and can always find logical reasons for whatever he wants.

The ENTJ individual is hearty and frank; a leader in activities, and able in his studies. He is usually good in anything that requires reasoning and intelligent talk. He is well-informed, and keeps adding to his fund of

knowledge. He may sometimes be more positive and confident than his experience in an area warrants.

MBTI and Academic Performance

The hypothesis that personality type is intimately related to learning style has been assiduously presented by Myers, Keirsey and Bates, Lawrence, and others. This hypothesis has been tested in the field by numerous researchers, and the results have been encouraging.

Mary McCaulley is an educational researcher who has done extensive research involving the MBTI. In her 1977 Journal of College Science Teaching article, McCaulley suggested that the MBTI could lead one to predict which types would be interested in science. She theorized that among science students and scientists, introverts would outnumber extroverts, intuitive types would outnumber sensing types, thinking types would outnumber feeling types in the physical sciences, and that feeling types would outnumber thinking types in the behavioral sciences. She followed up this theory with research on students at the University of Florida. The results of the study supported her theory. The study showed that there were significantly more NT types in the physical sciences and in engineering than in nursing and education; SF types were more attracted to nursing and education than to the humanities and sciences; There were more NF types in the

humanities and behavioral sciences than other types; and ST types were more attracted to biological than to behavioral or physical sciences. There was a significantly higher population of intuitive introverts, (IN), in the humanities, physical sciences and engineering than other types. The extroverted sensing types, (ES), were found in higher numbers in physical education, nursing, and business. The behavioral sciences were highly populated with intuitive extroverts, (EN). The introverted sensing, (IS) types show a significant avoidance of physical sciences and a preference for biological science. These results indicate conditional support for McCaulley's hypotheses in that some combinations of at least two personality traits predominated in certain subject areas, rather than individual traits as McCaulley had hypothesized.

Mary Budd Rowe (1978) assembled a profile of high school students in Florida who chose science as their major interest. The MBTI was used to characterize the students. The resulting profiles indicated that there was indeed a relationship between personality type as measured by MBTI and choice of course of study. It was found that the majority of students, (74.20 %), enrolled in a summer science program for high school students at the University of Florida were intuitive, (N), types. The NF types were significantly more attracted to the humanities

and behavioral sciences than other types. ST types were more attracted to the biological than to the behavioral and physical sciences. SF types were more attracted to nursing and education than other types.

Similar findings were obtained from both McCaulley's and Rowe's research. In both studies, NF types were found to predominate in humanities and behavioral sciences; ST types in biological sciences; and SF types in nursing and education.

Novak and Voss (April, 1981) found that for eighth grade science students, there was a statistically significant difference in scores earned on standard tests of intelligence between sensing and intuitive types, in favor of the intuitives; and between judging and perceiving types, in favor of the perceiving types.

Deines (1974) used two samples, each consisting of 150 undergraduate college students at Michigan State University to investigate the relationship between college major and cognitive style as measured by the MBTI. His research indicated that ES and IS types tended towards natural sciences, while EN types tended away from the natural sciences, and ET types tended towards the humanities.

Hockert (1975) looked at the relationship between MBTI type and choice of college major among 100 female and 100 male students. It was found that S type students

choose realistic majors. I, N, and T types choose investigative majors. EF individuals choose social majors. ST students choose conventional majors, and IN students choose artistic majors.

The MBTI has been studied as a possible predictor of overall academic success. Hengstler, Dennis, and others, (1981), found that when compared with the GPA of college freshmen at a predominantly female college, there was a low to moderate relationship between academic success and scores on the MBTI. The SN dimension showed a significant relationship to achievement in favor of the N's when dichotomous scores were used. When continuous scores were used, significant but low correlation was found between SN and GPA, as well as between JP and GPA.

Stone (1978) found that there was some relationship between MBTI factors and GPA as well as program completion rate for students.

Nisbet (1982) looked at predictors of academic success with high risk college students and found that the JP scale of the MBTI was moderately correlated with GPA.

Williams (1976) used 135 A.S. and 177 B.S. degree nursing students to investigate a correlation between Nursing Board scores and MBTI types. This research showed that no one type performed consistently higher or consistently lower on either the total exam or on the subscales.

Kramer (1977) looked for possible relationships between MBTI type and achievement in expository and creative writing among 646 college students. When higher grades were defined as "A" or "B" grades, and "C", "D", and "F" were defined as lower grades, it was found that the introverts tended to make the higher grades.

Weychert (1975) in considering student achievement compared the MBTI types of 1871 ninth and tenth graders with those of 46 of their English, Math, Science, and Social Studies teachers. Only the SN index of the MBTI was used. The results indicated that personality type could not be studied in isolation because there was an apparent interaction between teacher and student personality type and student sex. Sensing male students were less satisfied with intuitive teachers than with sensing teachers. However, it was found that generally students, regardless of type, were more satisfied with intuitive than with sensing teachers.

Reed (1977) used 73 eleventh and twelfth grade students from a small Bureau of Indian Affairs high school to compare MBTI types with a constructed semantic differential. The JP scale was found to be significantly related to the largest number (8), of semantic differential concepts. There were 19 concepts in all. In all 8 concepts, J scored higher than P.

Bloch (1978) studied 558 persons aged 17 to 75 and

representing the general population proportionally as to men and women, blacks and whites, and white collar and blue collar service workers, to see if the MBTI profile changes with age. The results indicated "that for the SN and JP dimensions, and the S and J preference, age contributes a suggestive amount of the variance in the determination of psychological type." The actual changes indicated were that individuals tend to increase their preference for S and J as they age.

Grosenbach (1976) looked for possible differences in MBTI personality types of students in a challenge curriculum and underachieving students in grades 7 through 12 at Burns Laboratory School, Ball State University. No personality differences were found between the students in the challenge curriculum and the underachieving students.

Millott (1975) investigated the possibility of correlations between MBTI personality types and college reading and study skills. Two thousand five hundred and fourteen college freshmen at the University of Florida in 1972 were used in the study."Very low but because of the large sample size significant correlations ($p<.001$) were found between paragraph comprehension and preference for MBTI personality types of Intuition, Introversion, and Perception. The correlations ranging from .07 to .18 accounted for less than 4 percent of the variance. Possible explanations for the low correlations include

homogeneity of the sample and suspected hostility of the students for long periods of orientation testing."

Summation

Colleges have used two approaches in response to the high failure rate in college chemistry. One approach has been to establish screening tests. The other has been to develop preparatory chemistry courses. Some colleges have used both of these approaches.

One research project, not related to failure, has shown that specific problem solving techniques are used in successfully solving physics problems. Physics and chemistry are both physical sciences and their course content frequently overlaps, so problem solving techniques used in physics are relevant to chemistry as well.

The various studies on academic achievement and the MBTI appear to indicate that there is some correlation between certain dimensions of personality traits and academic achievement. The EI, SN, and JP preferences have shown some correlation with achievement. Of these, the JP preference appears to have the most significant correlation with achievement. For statistical purposes, it is important to note that the EI, SN, and TF scales appear to be relatively independent of each other, but the SN and JP scales consistently correlate with each other. (Carlyn, 1977). The TF scale, the only one that shows a definite

relationship to sex difference (Myers, 1980), has not been correlated with general academic achievement in the recent literature.

Chapter 3

Research Methodology

Chapter Organization

Chapter Three is organized as follows. The purpose of the study, the research questions and hypotheses, are stated. The research design is described. Research instruments are discussed. The validity and reliability of these instruments are reported. The population, sample, and data collection procedures are described.

Purpose

The purpose of this study is to investigate relationships that might exist between achievement in college chemistry and problem solving style as measured by the MBTI.

Research Questions

Question 1

Is there a relationship between problem solving style as measured by the MBTI and achievement in College Chemistry 1? Problem solving style can encompass from one to a composite of four MBTI dimensions. Achievement in College Chemistry 1 is the same as the grade earned in Chemistry 111. The grades "A", "B", and "C" are passing grades. "D" and "F" grades indicate failure, and the "W" grade means that the student withdrew from the class.

Question 2

Does problem solving style based on the MBTI add to the variance explained by the Pretest? The Pretest explains some of the variance in grade and is a useful screening tool; however, an improvement on the prediction capability of this pretest is being sought.

Question 3

Is there a difference in the distribution of grades assigned by different instructors in College Chemistry 1? If the instructor has an effect on the final grade assigned to the student, then this would have to be taken into account when the relationships between the MBTI and achievement in College Chemistry 1 are examined.

Question 4

Is there a difference in grade distribution according to MBTI profile? The MBTI profile is that combination of four MBTI dimensions unique to an individual. There are sixteen possible combinations of four dimensions. These are described in Chapter 2 of this study. Only extreme differences in performance are likely to show up here.

Question 5

Is there a difference in problem solving style as

measured by the MBTI for students who pass College Chemistry 1 with a "C" or better grade, those who fail with a "D" or "F" grade, and those who withdraw from the course? (This is a narrower version of question 4.)

Question_6

Is there a difference in distribution of final exam scores by problem solving style as measured by the MBTI? The final exam is comprehensive.

Question_7

Is there a relationship between problem solving style as measured by the MBTI and final exam score? This requires an investigation of the variance of final exam score with any of the MBTI dimensions.

Hypotheses

Frequency distributions will be used to evaluate the tenability of the following hypotheses.

1. Students whose MBTI profiles include both N and T preferences will achieve higher grades in College Chemistry 1 than students whose profiles include both S and F preferences.

2. Students whose profiles contain the N preference combined with any three of the other possible preferences will achieve higher grades in College Chemistry 1 than

students whose profiles include the S preference combined with any three of the other possible preferences.

3. Students whose profiles contain the T preference in combination with any three of the other possible preferences will achieve higher grades in College Chemistry 1 than students whose profiles contain the F preference in combination with any three of the other possible preferences.

Research Design

The research design was ex post facto. Ex post facto is defined by Kerlinger (1973) as "systematic empirical inquiry in which the scientist does not have direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable. Inferences about relations among variables are made, without direct intervention, from concomitant variation of dependent variables."(P.379).

In the present study, the sample consists of Chemistry 111 students; the independent variables are Pretest and MBTI preferences; the dependent variables are final grade and final exam score. The Pretest score is not manipulable because the test had already been taken and the scores obtained. The MBTI preferences are not manipulable because they represent the inherent problem solving style of the individual. The existing variations

in final grade are statistically compared to variations in the Pretest score and differences in MBTI preferences, and thus inferences about relationships among these variables can be made without direct intervention.

Research Instruments, Reliability and Validity

There were three research instruments. The first one administered was the Pretest.. This is a 26 question paper and pencil test designed by the Chemistry Department at NVCC AN. The second instrument used was Form G of the MBTI, a paper and pencil inventory consisting of 126 questions. The third instrument was a 40 question final examination designed by the Chemistry Department at NVCC AN. All three instruments were multiple choice questionnaires.

The Pretest was patterned after the Toledo Chemistry Placement Examination (TCPE). It is shorter than the TCPE by 41 questions. It requires less time to take and gives results that are equal to or better than the TCPE. The TCPE is an American Chemical Society (ACS) publication that was developed and validated by the Examinations Committee of the ACS. The reliability and validity of both the Pretest and the TCPE were tested by the Chemistry Department faculty at NVCC AN. (NSF Cause Grant Final Report, 1982). In a measure of how well the Pretest discriminates among students, a KR20 reliability of 0.839

was obtained. The correlation of passing grade to Pretest score was R = 0.65. Identical analyses for the TCPE gave a KR20 of 0.92 and an R of 0.42.

When the MBTI is scored numerical values are obtained for each of the four dimensions, EI, SN, TF, and JP. These lead to composite MBTI profiles.

Carlyn (1977) assessed the results of several reports on the reliability and validity of the MBTI and based on these reports she concluded that the MBTI has adequate reliability and validity. A synopsis of the findings is presented here. Significant correlation was found between SN and JP dimensions. EI, SN, and TF dimensions were found to be independent of each other. Internal consistency of dichotomous scores was measured in a variety of ways. Phi coefficients for EI ranged from 0.55 to 0.65, for SN, from 0.64 to 0.73, for TF, from 0.43 to 0.75, and for JP, from 0.58 to 0.84. The internal consistency of continuous scores was checked by three different procedures and similar results were obtained for each. Coefficients ranged from 0.76 to 0.82 for EI, 0.75 to 0.87 for SN, 0.69 to 0.86 for TF, and 0.80 to 0.84 for JP. The stability of type category scores was found to be quite good. The agreement between original and retest scores was in a higher proportion than would be expected by chance. Expert evaluation of the MBTI by Jungian analysts credited the MBTI with excellent validity. Comparisons of

the MBTI with other instruments supported these validation results. In regard to predictive validity, it was found that the ability of the measure to predict varied with the sample under consideration. Numerous studies on construct validity led Carlyn to conclude that "the individual scales of the MBTI measure important dimensions of personality which seem to be quite similar to those postulated by Jung."

The instruments being used in this study as predictive tools appear to have acceptable reliability and validity.

Population and Sample

The population was made up of 159 students enrolled in Chemistry 111 during the Winter and Fall quarters, 1983, at NVCC AN. The sample consisted of students who were present for the first laboratory period of the quarter, and who volunteered to participate in the evaluation. There were 128 male and 31 female students in the sample. The ages ranged from 17 to 37 years for the 153 students who reported their ages. The actual age distribution is shown in Table 3.1.

Table 3.1

Age Distribution of Chemistry 111 Students

AGE	# of Students	%
17	5	3.27
18	18	11.76
19	31	20.26
20	28	18.30
21	16	10.46
22	8	5.23
23	14	9.15
24	8	5.23
25	7	4.58
26	5	3.27
27	4	2.61
28	0	0.00
29	1	0.65
30	0	0.00
31	2	1.31
32	0	0.00
33	1	0.65
34	1	0.65
35	1	0.65
36	0	0.00
37	3	1.96
	Total = 153	Total = 100.00

Data Collection Procedures and Analyses

All students wishing to enroll in Chemistry 111 must take the Pretest prior to registration. The Pretest is administered in a testing center where the students are proctored by college staff. The test is machine graded and the scores transferred to the computerized data base of student records.

The students who enroll in Chemistry 111 must attend a 3 hour laboratory class each week. There are several laboratory sessions, each of which can accommodate 20 students. The first 2 hours of each Chemistry 111 laboratory session during the first week of classes was dedicated to administration of the MBTI. The same researcher administered all the inventories. The completed inventories were hand scored by the researcher.

There is a College prescribed final examination schedule for each Chemistry 111 class. In the designated time-frame, the same final examination was administered to each class by the classroom teacher. The completed examinations were machine graded. The final grades were assigned by the classroom teachers. The final grades are based on chapter tests, laboratory scores, and the final exam score. These grades were added to the computerized student records.

Pretest scores were obtained from the student records, MBTI scores from direct scoring of the inventories, and

final grades from the Final Grade Reports.

The collected data was prepared for computerised statistical analysis. The statistical procedures used will be discussed in Chapter4. Research questions 1, 2, and 7 were analyzed by multiple regression analysis. Research questions 3, 4, 5, and 6 were analyzed by chi square analysis. The additional tests were frequency distributions.

Data Organization

The large body of data collected had to be organized so that it could be used to shed some light on the relationships among the variables, and most importantly, so that it could be in a useful form for addressing the research questions and hypotheses. The first task was to organize the data into meaningful subsets. In some instances the organization led directly to the answers to some research questions. In other instances, the organization simply subdivided the data and elucidated the relationships of variables in preparation for further statistical analysis related to answering specific research questions. The results of this process are displayed in Appendix B.

Summary

The research methodology was presented in this

chapter. The purpose of the study, the research questions, and the hypotheses were stated. These focussed on the thrust of this study which is to explore the possible relationships between problem solving style as measured by the MBTI and achievement in college chemistry. A description of this ex post facto design 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. There were descriptions of the population and sample, and an explanation of the data collection procedures.

Chapter 4

Chapter Organization

Chapter 4 is organized as follows. The sample is described in terms of sex, age, grade, and MBTI profile distribution. The statistical analyses are then presented in the same order as the research questions and hypotheses posed in Chapter Three.

Characteristics of the Sample

Each of the sixteen MBTI profiles was found in the sample. ISTJ was the most abundant profile with 18.87% of the sample falling into this category. The lowest representation was shared equally among INFJ, ESFJ, and ENFJ, each of which had a 1.26% representation in the sample. The MBTI profile distribution is displayed in Table 4.1.

The letter grades assigned to students were "A, B, C, D, F, and W" where the Letters A through F were used to indicate the student's performance in the course such that "A" was the highest possible grade and "F" was the lowest. The "W" grade indicated that the student withdrew from the course. 55% of the students in the sample passed the course with a "C" or better grade. 25% failed with a "D or F" grade, and 20% of the students withdrew. The complete grade distribution is shown in Table 4.1.

Table 4.1.

MBTI Profile vs. Grade Distribution for Chemistry 111

MBTI	W	F	D	C	B	A	Total	%
ISTJ	10	2	1	4	10	3	30	18.87
ISTP	2	4	1	4	2	2	15	9.43
ISFJ	1	3	1	4	1	0	10	6.29
ISFP	2	0	0	3	1	0	6	3.77
INTJ	3	3	0	5	2	1	14	8.81
INTP	2	3	1	4	0	1	11	6.92
INFJ	0	2	0	0	0	0	2	1.26
INFP	3	2	1	2	2	1	11	6.92
ESTJ	3	1	3	2	6	4	19	11.95
ESTP	0	2	2	2	0	0	6	3.77
ESFJ	0	0	0	1	1	0	2	1.26
ESFP	2	0	0	0	1	0	3	1.89
ENTJ	0	0	1	6	4	2	13	8.18
ENTP	2	2	3	0	3	1	11	6.92
ENFJ	1	1	0	0	0	0	2	1.26
ENFP	1	0	1	2	0	0	4	2.52
Total	32	25	15	39	33	15	159	100.0
%	20	16	9	25	21	9	100	

Findings

Research Question 1

A correlation matrix and multiple regression analysis were used to answer the question, is there a relationship between problem solving style as measured by the MBTI and achievement in College Chemistry 1? First, a data set containing all students who persisted in the course was created. There were 127 cases with grades ranging from "A" to "F" in this data set. The pertinent correlations for Grade were -0.021 with EI, -0.168 with SN, -0.133 with TF, and -0.151 with JP. These indicate that the higher the grade, the more likely the profile to contain E,S,T, and J preferences. A multiple regression of Grade versus EI, SN, TF, and JP, showed that SN explains 2.84% of the variance; with TF entered, 4.01% is explained: When JP is entered 4.52% of the variance is explained: Finally, with EI in the equation, 4.57% of the variance is explained. The final r squared value was 0.0457 and the multiple r value was 0.2137. Table 4.2 is the resultant ANOVA table.

Research Question 2

There were 97 cases that included students who took the Pretest and persisted in the course. This subset of the sample was used to try to answer the question, does problem solving style based on MBTI type add to the variance

Table 4.2

Regression Analysis of Final Grade Against MBTI Dimensions for All Persisters

Number of cases = 127 EI, SN, TF, and JP entered

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F Ratio
Regression	9.5	4	2.4	1.5
Residual	198	122	1.6	
Total	207.5	126		

explained by the Pretest? The correlation with Grd for Prt was 0.261, for EI, -0.015, for SN, -0.153, for TF, -0.178, and for JP, -0.134. (Table 4.7). A multiple regression analysis of Grd versus Prt, SN, TF, and JP was done. EI was omitted because of its low correlation with Grd. Prt was entered first into the equation and explained 6.79% of the variance. SN was entered next and the explanation of variance was increased to 9.79%. When JP was entered, this increased to 11.07%. Finally, with TF entered, 11.41% of the variance was explained. The final r squared value was 0.1141, and the multiple r value was 0.3378. The resultant ANOVA table is contained in Table 4.3

Table 4.3

Regression Analysis of Final Grade Against MBTI Dimensions for Students Who Took the Pretest and Persisted

Number of Cases = 97 SN, TF, JP, and Pretest entered

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F Ratio
Regression	19	4	4.9	3.0
Residual	151	92	1.6	
Total	170	96		

Research Question 3

Chi square analysis was used to answer the question, is there a difference in the distribution of grades assigned by different instructors in College Chemistry 1? The row variable was Grade. The value zero represented the "W" grade. Values one through five represented grades "F" through "A". Numbers arbitrarily assigned to individual instructors were used for the column variable. There were six different instructors involved. Their assigned numbers were 1,2,4,5,7,and 9. The analysis yielded a chi square value of 38.28 with 25 degrees of freedom. The experimental value is larger than the table value of 37.65 at the 0.05 level so the null hypothesis should be rejected. These results suggest that it is not true that for grades "A" through "F" and "W", there is no difference in grades assigned by different instructors.

The cases which included a "W" grade were removed from the data set and a chi square analysis using grades "F" through "A" and the same six instructors was run. The value of chi square for this set was 29.673 and there were 20 degrees of freedom. This result is smaller than the table value of 31.41 at the 0.05 level and so the null hypothesis must be accepted. It has been shown that there is no difference in grades "A" through "F" assigned by different instructors.

Research Question 4

The method used to answer the question, is there a difference in grade distribution according to MBTI profile, was chi square analysis. Two analyses were performed. The 16 MBTI profiles were used as the row variable. For one analysis, the five grades "A" through "F" were used as the column variable. The resultant chi square value of 66.56 with 60 degrees of freedom had a p value of 0.74 indicating that the null hypothesis should be accepted. A second test was performed using the six possible grades, "A" through "F" and "W" as the column variable. The resulting chi square value was 83.751 with 75 degrees of freedom. These results were compared with values stored in the computer and showed that there was a 77.11% probability of any differences being due to chance. This meant that the null hypothesis should be accepted. The results of both chi square analyses

indicated that there is no difference in grade relative to MBTI profile distribution.

Research Question 5

Chi square analyses were used to answer the question, is there a difference in problem solving style as measured by the MBTI for students who pass College Chemistry 1 with a "C" or better grade, those who fail College Chemistry 1 with a "D" or "F" grade, and those who withdraw from the course? The sample was divided into sets containing cases with "W" grades, "D" and "F" grades, and "C" or better grades. For each set, the sixteen MBTI profiles were used as the row variable. The three column variables were "W" grade, "D" and "F" grades, and "C" or better grades. The results of the chi square analysis indicated that the null hypothesis should be accepted. The 16 by 3 table yielded a chi square of 41.83 with 30 degrees of freedom. This is lower than the table value of 43.77 at the 0.05 level, so the null hypothesis must be accepted; there is no difference in problem solving style as measured by the MBTI for students who pass College Chemistry 1 with a "C" or better grade, those who fail with a "D" or "F" grade, and those who withdraw from the course.

Research Question 6

Differences in problem solving style as measured by the MBTI and distribution of final exam scores were examined through chi square analysis. The two students with ENFJ profiles did not take the final examination. The remaining fifteen MBTI profiles were used as the row variable. The final scores were arranged in percentage groupings equivalent to letter grades. These five groups were used as the column variable. One group contained percentages zero to fifty nine which is equivalent to an "F". Another contained percentages sixty to sixty nine which equates to a "D". The seventy to seventy nine percent group is equivalent to a "C". Eighty to eighty nine percent represents a "B", and ninety to one hundred percent is equivalent to an "A". The analysis resulted in a chi square value of 50.50 with 56 degrees of freedom. Computer analysis of these results gave a p value of 0.32 which indicate that the null hypothesis should be accepted. There is no difference in the distribution of final scores among MBTI profiles.

Research Question 7

The four dimensions, EI, SN, TF, and JP were used in a multiple regression analysis with final exam score as the dependent variable in an effort to answer the question, is there a relationship between problem solving style as

measured by the MBTI and final exam score? JP was the first variable to be entered into the equation. It explained 0.80% of the variance. SN was entered next and the explanation of variance increased to 1.70%. TF was entered third and explanation of variance increased to 1.97%. The EI dimension added nothing to the variance. The relationships were in favor of J, N, and T. The r squared value was 0.0197, and the multiple r was 0.1405. Table 4.4 contains the resultant ANOVA table.

Table 4.4

Regression Analysis of Final Exam Score Against MBTI Dimensions for All Who Took the Final Exam

Number of cases = 116 SN, TF, and JP entered

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F Ratio
Regression	545	3	182	0.75
Residual	27045	112	241	
Total	27590	115		

Hypothesis 1

Frequency distributions shown in Tables 4.5 and 4.6 were designed to test the hypothesis that students whose MBTI profiles include both N and T preferences will achieve higher grades in College Chemistry 1 than students whose profiles include both S and F preferences. 59.18% of the NT

students earned grades of "C" or better, while 57.14% of the SF students did likewise. The NT students performed slightly better than the SF students.

Table 4.5

Grade Distribution for NT Students

Grade	Frequency	Percent	Cumulative Percent
A	5	10.20	10.20
B	9	18.37	28.57
C	15	30.61	59.18
D	5	10.20	69.39
F	8	16.33	85.71
W	7	14.29	100.00
Total = 49			

Table 4.6

Grade Distribution for SF Students

Grade	Frequency	Percent	Cumulative percent
A	0	0.00	0.00
B	4	19.05	19.05
C	8	38.10	57.14
D	1	4.76	61.90
F	3	14.29	76.19
W	5	23.81	100.00
Total = 21			

Hypothesis_2

Tables 4.7 and 4.8 show frequency distributions used to determine whether or not students whose profiles contain the N preference combined with any three of the other possible preferences would achieve higher grades in College Chemistry 1 than students whose profiles include the S preference combined with any three of the other possible preferences. 56.04% of the S students as compared with 52.94% of the N students obtained a "C" or better grade. Contrary to expectations, the S students slightly outperformed the N students.

Table 4.7

Grade Distribution for S Type Students

Grade	Frequency	Percent	Cumulative Percent
A	9	9.89	9.89
B	22	24.18	34.07
C	20	21.98	56.04
D	8	8.79	64.84
F	12	13.19	78.02
W	20	21.98	100.00
Total = 91			

Table 4.8

Grade Distribution for N Type Students

Grade	Frequency	Percent	Cumulative Percent
A	6	8.82	8.82
B	11	16.18	25.00
C	19	27.94	52.94
D	7	10.29	63.24
F	13	19.12	82.35
W	12	17.65	100.00
Total = 68			

Hypothesis 3

The frequency distributions in Tables 4.9 and 4.10 were used to examine the hypothesis that students whose profiles contain the T preference in combination with any of the three other possible preferences will achieve higher grades in College Chemistry 1 than students whose profiles contain the F preference in combination with any three of the other possible preferences. 56.41% of the T students as compared with 50.00% of the F students earned "C" or better grades. The T students outperformed the F students to a moderate extent.

Table 4.9

Grade Distribution for T Type Students

Grade	Frequency	Percent	Cumulative Percent
A	14	11.97	11.97
B	27	23.08	35.05
C	25	21.37	56.42
D	12	10.26	66.68
F	17	14.53	81.21
W	22	18.80	100.01
Total = 117			

Table 4.10

Grade Distribution for F Type Students

Grade	Frequency	Percent	Cumulative Percent
A	1	2.38	2.38
B	6	14.29	16.67
C	14	33.33	50.00
D	3	7.14	57.14
F	8	19.05	76.19
W	10	23.81	100.00
Total = 42			

Additional Tests

Some additional tests were performed in an effort to extract more elucidative information from the data. These additional tests consisted of quantitative and descriptive analyses. Through frequency distributions and regression analyses, detailed profiles of students who

passed, those who failed, and those who withdrew from the course were obtained. In addition, the NVCC AN chemistry students were compared with engineering and science students at four year colleges by means of chi square analyses. A complete discussion of these additional tests is included in Chapter Five.

Summary

The sample was found to be quite diverse in that all 16 MBTI profiles were represented. There were overwhelmingly more male than female students. A large proportion of the students, 60.78%, were in the traditional college-age group of 18 to 21 year olds. Answers were obtained for all the research questions and hypotheses. Some of the results were not what was expected. An allusion was made to the additional tests that were performed. A complete discussion of results can be found in Chapter 5.

Chapter 5

Results and Conclusions

Chapter Organization

This chapter is organized as follows. A tabular summary of the statistical analyses used to respond to research questions and hypotheses is presented. Each research question is restated in turn, along with the results and inferences that can be drawn from the statistical analyses used to answer the particular question. Profiles of successful students, failing students, and students who withdraw are presented. Overall conclusions about the study are drawn. Additional research is presented. Recommendations based on the results of the study are made.

Table 5.1

Summary of Multiple Regressions

Research Question	Dep.Var.	Method	Ind.Var. by entry	Regr. Coef.	Succ. R sq.
#1	Grd	Stepwise	SN	-0.01	0.03
			TF	-0.01	0.04
			JP	-0.004	0.05
			EI	-0.001	0.05
#2	Grd	Stepwise	Prt	0.05	0.07
			SN	-0.01	0.10
			JP	-0.01	0.11
			TF	-0.004	0.11
#7	Fsc	Stepwise	JP	-0.05	0.01
			SN	0.07	0.02
			TF	-0.04	0.02
			EI	0.001	0.02

Table 5.2

Summary of Chi Square Analyses

Research Question	Row Vars.	Column Vars.	Chi Sq.	D.F.	Value @ 0.05	Ho
#3	A - W	Instr	38.28	25	37.65	reject
#3	A - F	Instr	29.67	20	31.41	accept
#4	MBTI	A - W	83.75	75	*	accept
#4	MBTI	A - F	66.56	60	**	accept
#5	MBTI	W D & F C & Up	41.83	30	43.77	accept
#6	MBTI	Fsc	50.50	56	***	accept

* Computer analysis shows p = 0.77
** Computer analysis shows p = 0.74
*** Computer analysis shows p = 0.68

Synopsis of Results

The following flow charts are a summary of the results obtained for the research questions, and the hypotheses. Their purpose is to provide an overview of the important results.

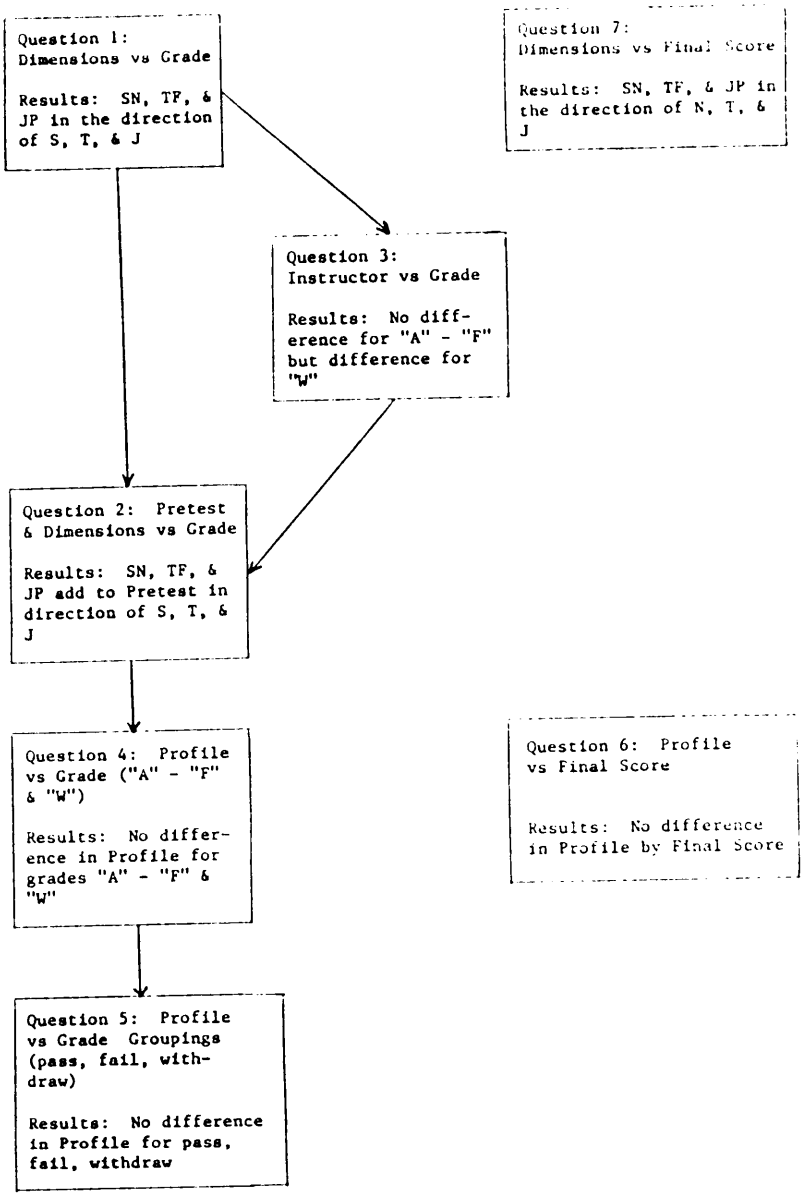


Figure 5.1
Synopsis of Research Questions and Results

Research question 1 led to research question 2. Research question 3 was a support question for questions 1 and 2. Research question 2 led to research question 4 which led to research question 5. Research question 7 was on the same level as question 1 but a different variable was used to measure achievement. Similarly, research question 6 was on the same level as research question 4. The results for these questions are displayed in Table 5.1.

Research Question 1

The multiple regression analysis used to answer research question 1 revealed that there is some relationship between problem solving style as measured by the MBTI and final grade in College Chemistry 1. The variance explained by the MBTI dimensions EI, SN, TF, and JP was quite small, amounting to only 4.57% after all four variables were entered into the equation. The regression indicated that the EI preference added very little to the variance. The explanation of variance increased by only 0.05% when EI was finally added to the equation. (Table 5.1). It appears then that there is negligible relationship between final grade and extroversion-introversion. The SN, TF, and JP relationships to final grade were in the direction of S, T, and J. This means that the higher the grade the more

likely that the preferences will be S, T, and J.

Research Question 2

The Pretest explained more variance than any other variable. However, some dimensions of the MBTI did add to the variance explained by the Pretest. Multiple regression analysis (Table 5.1), showed that for 97 students who took the Pretest and went on to earn grades ranging from "A" to "F", the Pretest explained 6.97% of the variance. The addition of the SN dimension to the equation caused a 3% increase in the explanation of variance. The entry of JP into the equation caused a 1.28% increase, and finally, TF caused a 0.34% increase. So the explanation of variance went from 6.79% to 9.79%, to 11.07%, and finally to 11.41%. Clearly, the SN, TF, and JP dimensions of the MBTI add to the variance explained by the Pretest. The relationships were in favor of higher Pretest scores, S, T, and J preferences. This indicates that more students with high Pretest scores and S, T, and J preferences earned high grades in College Chemistry 1 than other students. The fact that the majority of students enrolled were STJ types may in part account for this. Table 4.2 shows that 18.87% were ISTJ and 11.95% were ESTJ; so 30.82% of all enrolled students were STJ. These results are in agreement with those obtained for research question 1.

Research Question 3

Chi square statistics, (Table 5.2), suggest that while there is a difference in "A" through "F" and "W" grades assigned by different instructors, there is no difference in grades "A" through "F" and not including "W" assigned by these same instructors. The obvious inference is that there is a difference in the "W" grade assignments for these instructors. Indeed, 50% of the students in a particular instructor's class withdrew from the course. The closest to this was 21% for another instructor. The others were 20. 19, and 13%. Students withdrew at a much higher rate from one instructor's class than from any other. For the students who remained in class, there was no difference in assignment of grades "A" through "F" by different instructors.

These results indicate that it is possible to look at achievement in College Chemistry 1 in terms of grades "A" through "F" without taking instructor into consideration.

Research Question 4

Based on the answers to research questions 1 and 2, one would expect there to be a difference in grade distribution according to MBTI profile. However, chi square analysis, (Table 5.2), shows that for grades "A" through "F" there is no difference in grade distribution

according to MBTI profile. When the "W" grade is included, there is still no difference in grade distribution with MBTI profile. An explanation for this apparent dichotomy of results between multiple regression and chi square is that chi square takes proportions within each group into account while multiple regression does not. Another is that the two statistics measure two different aspects of the MBTI; chi square measures the composite profile or intact preference; multiple regression uses continuous scores of the MBTI dimensions.

Research Question 5

Chi square analyses, (Table 5.2), show that there is no difference in problem solving style as measured by the MBTI for students who pass College Chemistry 1 with a "C" or better grade, those who fail with a "D" or "F" grade, and those who withdraw from the course. This result supports that obtained for research question 4. Taken together, these results indicate that statistically, for the composite profiles, there is no difference in grades "A" through "F" and "W". Students pass, fail, and withdraw in the same proportions across the sixteen MBTI profiles. The relation of grade to problem solving style must not then lie in the composite profile.

Research Question 6

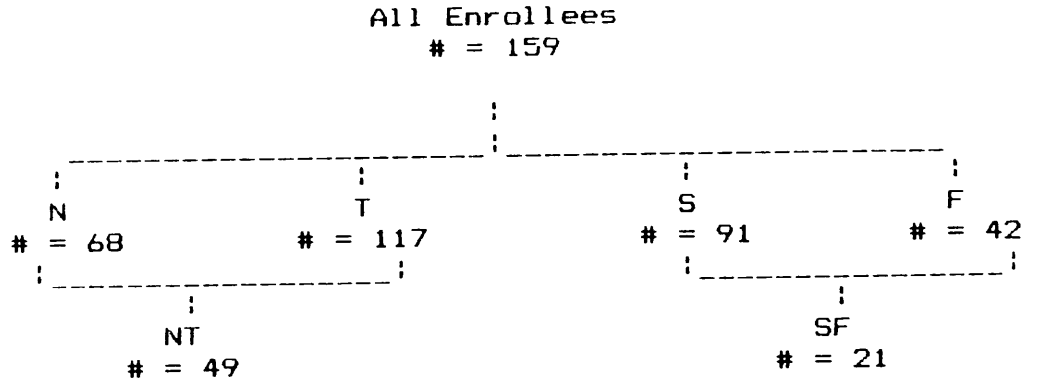
The final examination in College Chemistry 1 is comprehensive. It also consists of about 67% analysis type questions. Thus, achievement on the final examination could be a measure of performance in the course, as well as ability to correctly answer analysis type questions. The question posed was, is there a difference in problem solving style as measured by the MBTI and distribution of final exam scores? A chi square analysis of the sixteen MBTI composite profiles and final exam scores in percentage groupings equivalent to letter grades suggests that no such difference exists. (Table 5.2).

Research Question 7

Multiple regression was used to search for a relationship between problem solving style as measured by the MBTI and final exam score. (Table 5.1). The four dimensions of the MBTI were regressed against final exam score. JP was entered into the equation first and explained 0.08% of the variance. Next to be entered was SN which caused an increase to 1.70% explanation of variance. TF was the third entry and this caused an increase to 1.97% explanation of variance. EI did not add to the explanation of variance. The EI dimension is not related to final exam score. There are small

relationships between final exam score and the SN, TF, and JP dimensions. These relationships were in the direction of N,T, and J, indicating that preferences for intuition, thinking, and judging would favor higher scores on the final examination.

The chart in Figure 5.2 shows the data reduction for the hypotheses.



Hypotheses	Results
1. NT vs SF	NT ~> SF
2. N vs S	S ~> N
3. T vs F	T > F

Figure 5.2

Data Reduction for N, T, S, & F Preferences
With Hypotheses and Results

In terms of performance on analysis type questions on the final examination the results were as follows:

NT >> SF

N > S

T >> F

The foregoing synopsis of the hypotheses and results was for a quick overview. A full explanation of the results of analyses follows.

Hypothesis 1

The frequency distributions in tables 4.6 and 4.7 provided weak support for the hypothesis that NT type students would achieve higher grades in College Chemistry 1 than SF type students. Although a higher percentage of NT students passed the course than SF students, the difference was marginal. Under these circumstances the hypothesis is untenable.

Hypothesis 2

The hypothesis that N type students would outperform S type students in College Chemistry 1 was negated by the frequency distributions in tables 4.8 and 4.9. S type students did slightly better than N type students in the course. This is the reverse of expectations based on published results of other studies.

Hypothesis 3

Tables 4.10 and 4.11 display frequency distributions that show moderate support for the hypothesis that T type students would achieve higher grades in College Chemistry 1 than F type students. 6.41% more T type students earned a passing grade than F type students. These results are of course logically interconnected with the results for Hypotheses 1 and 2. Since NT is slightly better than SF, and S is better than N, then T must be better than F to a greater extent than S is greater than N if the relationship between NT and SF is true. In other words, Hypotheses 1, 2, and 3 are elucidative corollaries of each other.

Inferences

The multiple regression analyses indicate that there is some relationship between the Pretest, the MBTI dimensions, SN, TF, and JP, and achievement in College Chemistry 1.

Chi square analyses indicate that any differences in achievement in relationship to MBTI composite profile is so small as to be statistically negligible.

There is slight support for Hypotheses 1 and 3, but no support for Hypothesis 2. NT students performed slightly better than SF students, T students performed slightly better than F students, but S students performed slightly

better than N students.

In order to extract more useful information from the data, quantitative and descriptive analyses were performed. These are included in the following student profiles.

Profile of Successful Students

The students who earned a "C" or better grade were the successful students. Of the 159 students in the sample, 87 fell into this category. Of these successful students, 59.77% were introverts, 62.07% were sensing types, 78.16% were thinking types, and 64.37% were judging types. This points to ISTJ as the composite profile for most of the successful students. Indeed, a frequency distribution of the sixteen MBTI composite profiles for successful students confirms that ISTJ has the highest representation with 19.54%. (Table 5.3). The next highest representation was found in ESTJ and ENTJ, each of which accounted for 13.79% of the successful students. The commonality among these three groups is TJ. There are some introverts, some extroverts, some sensing types, and some intuitive types among the majority of successful students, but the thinking and judging preferences are found exclusively among the majority of successful students.

Table 5.3

MBTI Distribution for "C" or Better Students

Profile	Frequency	Percent	Cumulative Percent
ISTJ	17	19.54	19.54
ISTP	8	9.20	28.74
ISFJ	5	5.75	34.48
ISFP	4	4.60	39.08
INTJ	8	9.20	48.28
INTP	5	5.75	54.02
INFJ	0	0.00	54.02
INFP	5	5.75	59.77
ESTJ	12	13.79	73.56
ESTP	2	2.30	75.86
ESFJ	2	2.30	78.16
ESFP	1	1.15	79.31
ENTJ	12	13.79	93.10
ENTP	4	4.60	97.70
ENFJ	0	0.00	97.70
ENFP	2	2.30	100.00

The fact that the TJ combination is most frequently associated with success in College Chemistry 1 is clearly demonstrated in Table 5.4.

Table 5.4

TJ, TP, FJ, & FP Distribution for "C" or Better Students

	J	P
T	56.35%	21.85%
F	8.05%	13.80

The statistical procedures used to answer Research Question 2 indicated that the Pretest has the strongest correlation with final grade in College Chemistry 1 of any

variables used. For the successful students, it is expected that Pretest, TF, and JP dimensions would contribute significantly to the variance in grade. The results of a multiple regression of Pretest, TF, and JP against grade for the "C" or better group supports this contention. (Table 5.5). Pretest explains 10.75% of the variance. The inclusion of TF in the equation increases the explanation to 14.56%. Finally, with JP added, 15.55% of the variance is explained. The correlations are such that the higher the Pretest score, the closer to T and to J, the higher the grade.

Table 5.5

Regression Analysis of Final Grade Against MBTI Dimensions for "C" or Better Students

Number of cases = 63 Pretest,TF, and JP entered

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F Ratio
Regression	5.11	3	1.70	3.62
Residual	27.78	59	0.47	
Total	32.89	62		

The student with the highest probability of passing College Chemistry 1 with a "C" or better grade is one who earns a high Pretest score and has the TJ combination in

his MBTI profile.

Profile of "D" and "F" Students

Thirteen of the sixteen MBTI profiles were found in the "D" and "F" category. The three profiles not represented were ISFP, ESFP, and ESFJ, which contained 6, 3, and 2 students overall, respectively. These numbers are such a small portion of the 159 case sample that no statistical inference can be made about their omission from the group of failing students.

Of the four MBTI dimensions, EI, SN, And TF had the highest correlation with grade for the "D" and "F" students: The values were -0.379, -0.217, and -0.210 respectively. The value for JP was -0.002. Pretest score had a correlation value of -0.162 with grade for this group of students. These results indicate that the closer to E, S, and T, and the lower the Pretest score, the greater the likelihood of earning a "D" rather than an "F" grade. In any event, these preferences relate to failure of the course. The four variables, Pretest, EI, SN, and TF were regressed against "D" and "F" grades. (Table 5.6). EI was entered first and explained 14.33% of the variance. Next came TF which caused the explanation to increase to 19.80%. This was followed by Pretest which took the explanation to 24.07%. Finally, with SN entered 24.59% of the variance was explained.

Table 5.6

Regression Analysis of Final Grade Against MBTI Dimensions for "D" & "F" Students

Number of cases =34 EI, SN, TF, and Prt entered

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F Ratio
Regression	1.91	4	0.48	2.36
Residual	5.86	29	0.20	
Total	7.76	33		

These results suggest that the student most likely to fail with a "D" grade is one who obtains a low score on the Pretest and has an EST problem solving style.

Profile of students Who Withdraw

The group of students who withdrew from the course was overwhelmingly populated with ISTJ types. This problem solving style accounted for 31.25% of withdrawals with the closest follower being INTJ with 9.38%. INFJ, ESTP, ESFJ, and ENTJ were not among the withdrawals.This information is derived from table 4.4. The number of students inthe INFJ, ESTP, and ESFJ categories were 2, 6, and 2 respectively. These numbers are so small compared with the 159 enrollees overall that their exclusion from the withdrawals cannot

lead to any significant inference. There were 13 students classified as ENTJ. one earned a "D" and the twelve others earned a "C" or better grade. So the exclusion of ENTJ's from the withdrawals does have some significance. ENTJ's form a small but significant portion of the sample and 92.3% of them were successful in College Chemistry 1. It can be inferred that there is a low probability of a student with an ENTJ profile withdrawing from the course.

Almost all profiles can be found among the withdrawals. ISTJ is the most likely profile for a withdrawal, and ENTJ is the most unlikely.

Additional Tests

The NVCC AN College Chemistry 1 students are predominantly science and engineering majors. For this reason their MBTI profile distribution was compared to those of engineering majors and of science majors listed in Isable Briggs Myers' Gifts Differing. The comparisons were made by means of chi square analyses. The sixteen MBTI composite profiles were used as the row variable. The three different column variables were NVCC students, engineering majors, and science majors. The comparison of NVCC students and engineering students gave a 16 by 2 cell matrix which resulted in a chi square of 67.08 with 15 degrees of freedom. This was larger than the table value of 25.00 at the 0.05 level so the null hypothesis had to be

rejected. The conclusion was that it is not true that there is no difference in MBTI profiles for NVCC College Chemistry 1 students and engineering majors. A similar chi square analysis of NVCC students and science majors yielded a chi square of 137.42 with 15 degrees of freedom. These results led to the conclusion that these were two very dissimilar samples. When the MBTI profiles of the engineering majors and the science majors were compared, chi square of 156.28 with 15 degrees of freedom was obtained. Again, since the table value at 0.05 is 25.00 these results indicate quite dissimilar samples. The distributions of MBTI profiles were mutually different for the engineering majors, science majors, and NVCC College Chemistry 1 students.

In an effort to investigate the performance of thinking (T), and intuitive (N) problem solving styles as compared with their counterparts, the feeling (F) and sensing (S) problem solving styles, the frequency distributions were constructed. Bloom's (1971) taxonomy was applied to the final examination and analysis type questions identified. The percentage of correctly answered analysis type questions were noted for each case. The frequency distributions of percentages of correctly answered analysis type questions for NT, SF, N, S, T, and F types were obtained. The passing score was set at 70% because this is the lower limit of a "C" grade. For NT,

28.57% passed. None of the SF students passed. Thorsland and Novak's (1981) intuitive and analytic approaches are eqiivalent to the NT problem solving style. As would be expected from Thorsland and Novak's work, NT students are better at analytic problem solving than their counterparts. When the combinations are broken apart to examine individual preferences a broader spectrum of problem solving types are included. N types include NF and NT. S types include SF and ST. T types include ST and NT. F types include SF and NF. 26.47% of N types as compared to 18.46% of S types passed. There were 25.97% T types and 4.55% F types in the passing group. There is a larger gap between T and F than between S and N. It appears that the T preference is more strongly indicative of the ability to solve analysis type problems than F, S, or N preferences. This is supportive of the postulate that the T preference is analagous to an analytic problem solving approach.

Conclusions

Students with all the possible problem solving styles measured by the MBTI are attracted to College Chemistry 1. The ISTJ profile is attracted in the largest numbers and can be found in all final grade categories. The ENTJ profile is attracted in modest numbers but is the most successful proportionately. In addition to high Pretest

score, the TJ combination in a problem solving style is most indicative of probable success in the course. A low Pretest score along with an EST combination in problem solving style is most indicative of probable failure. Any problem solving style can potentially be found among the withdrawals but ENTJ is the most unlikely and ISTJ is the most abundant.

NVCC AN College Chemistry 1 students seem to be unique. They are different from four year college engineering majors and science majors. Contrary to expectations from MBTI literature, a large number of students with feeling and sensing preferences enroll in the physical science, College Chemistry 1. In addition to enrolling in the course, significant numbers of these students pass it.

Only a slightly smaller proportion of SF students as compared to NT students passed the course. This is different from what was expected based on the literature which suggested that NT students would do much better than SF students. (See Chapter 2 of this study). Results for T versus F type students were in keeping with expectations based on the literature in that T type students outperformed F type students on analysis type questions.

Carlyn (1977) has said that the SN and JP dimensions correlate with each other. This study shows that the JP dimension is more indicative of achievement in College

Chemistry 1 than the SN dimension. It may be that those characteristics of the SN dimension that are important to problem solving in college chemistry are more strongly manifested in the JP dimension.

McCaulley (1977) reported that IS types avoid the physical sciences. In this study, IS types were predominant enrollees in college chemistry, a physical science.

Rowe (1978) found the majority of science students to be N rather than S types. The reverse is true for College Chemistry 1 where 57.23% of the enrollees were S types.

The TF scale was not reported in recent MBTI literature to have a correlation with achievement, yet in the present study TF was consistently among the variables that corelated with achievement.

Some of the results of this study were in agreement with the literature. The fact that there was no statistical difference in MBTI composite profiles and grade distribution was similar to Williams' (1976) results which showed that no one type performed consistently differently than any other type on the Nursing Board Examination. Another point of agreement with the literature was that SN and JP dimensions correlate with achievement. (Hengstler, Dennis, and others, 1981.)

The results obtained for this study might in part be expalined by the factors that contribute to the final grade

in college chemistry at NVCC AN. Contributions to the final grade are apportioned as follows:

Laboratory --- 25%

Class Score --- 50%

Final Exam Score --- 25%

It is possible to speculate on learner behavior based on MBTI preference as explained by Lawrence (1979) in relation to each of the three components of final grade. The following explanation is such a speculation.

The laboratory portion of the course is a practical hands-on exploration of theory and facts and as such would tend to favor the S preference.

The classroom experience can be applicable to both S and N preferences because portions of the experience require the working of problems for which there are standard solutions: This is a strongpoint for the S preference, but students with the N preference can perform well on these problems also. Some of the classroom experience requires the working of problems with non standard solutions. Students with the N preference would be favored over those with the S preference on these problems.

The results of tests involving the analysis type problems shows that the final examination favors the N preference.

It is possible that students with the S preference might perform better in the laboratory than students with the N preference. It has been shown that students with the N preference performed better on the final examination than students with the S preference. Since the laboratory portion of the score and the final examination each contribute 25% the final grade it is possible that the results of these might offset each other. The class score could be about even for and N preferences. In this sample there were more S than N type students and this together with the foregoing may be the reason why the S preference was favored in the regression analyses.

The MBTI appears to be a useful tool for identifying problem solving styles that relate to achievement in particular fields of study. Correlations seem to be specific to the sample. What is true for community college students may not be true for high school, or four year college students.

Recommendations

It is recommended that those portions of the MBTI that measure the TF and JP dimensions be extracted and administered to potential enrollees in the College Chemistry 1 course, along with the Pretest. All students who earn high Pretest scores should be allowed to enroll. Students in this category who have TJ problem solving

styles should be directed to different sections of the course than the other students. The curriculum should continue to be the same for all sections. The achievement of the TJ students should be compared to that of the other students to see if it is higher. This should be monitored for at least three quarters. If the achievement of the TJ students is manitained at a higher level than that of other students, this segregation should continue. The possibility of separating other students according to the three other problem solving styles, TP, FJ, and FP should be investigated. Pedagogical strategies that would facilitate learning by students with these different problem solving styles should be developed.

The traditional lecture method is suited to the TJ learner who embodies a tolerance for routine, a need to work according to plans, the use of step-by-step, logical reasoning based on facts and theories. FJ students need a congenial environment but can also benefit from the lecture method.

An unstructured, investigative method of learning is conducive to the FP type student who also needs a congenial atmosphere. The TP student can benefit from this method as well but does not need a congenial atmosphere.

The lecture method is used at NVCC AN. Four of the six instructors in the study completed the MBTI and were found to be TJ types. It would be beneficial to FP and TP

students if the learning laboratory could be expanded to allow them to gain at least part of their required curricular input from properly supervised but unstructured investigations of their own choosing. This is probably contrary to the natural inclinations of the instructors but could be a pedagogical improvement for TP and FP students.

In regard to future research in this area of study it is suggested that the relationships between MBTI preferences and achievement in the individual portions of college chemistry be investigated. In particular, the laboratory and classroom performances of students with an S preference should be compared with those of students with an N preference.

Summary

The research questions and hypotheses were statistically and logically addressed. Some of the findings concurred with expectations based on MBTI literature, others did not. Community college chemistry students were found to be a unique population in regard to problem solving style. The most important finding was that this population can be characterized in terms of problem solving style, and that these problem solving styles are correlated with achievement in college chemistry. The purpose of the study was fulfilled.

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APPENDIX A

SAMPLE COLLEGE CHEMISTRY QUESTION

APPENDIX A

The following is a typical college chemistry question.

The commercial production of water gas utilizes the reaction:

$$C_{(s)} + H_2O_{(g)} \longrightarrow H_{2(g)} + CO_{(g)}$$

The heats of formation in kcal. for $CO_{(g)}$, $H_2O_{(g)}$, and $CO_{2(g)}$ respectively are:- -26.4, -57.8, and -94.1

The required heat for this endothermic reaction may be supplied by adding a limited amount of air and burning some carbon to carbon dioxide. How many grams of carbon must be burned to CO_2 to provide enough heat for the water gas conversion of 100 grams of carbon? Neglect all heat losses to the environment. (Schaum's Outline Series, College Chemistry (5th ed.), 1966, p. 148).

Solution:

In order to solve this problem, the student must know the equation for heat of reaction. He must also know the theory of stoichiometry. The student must comprehend what burning implies chemically and be able to translate words into a chemical equation. He must be able to apply the equation for heat of reaction and the theory of stoichiometry. The student must be able to analyze what is taking place chemically, understand the meaning of endothermic and exothermic and relate these concepts to the problem. Only after doing all of this can the student apply the simple mathematical tasks necessary for final solution of the problem.

APPENDIX A (cont.)

$$C_{(s)} + H_2O_{(g)} \longrightarrow H_{2(g)} + CO_{(g)}$$

The equation is balanced so it is alright to proceed. (Analysis).

$$\Delta H_{reaction} = \Delta H_{products} - \Delta H_{reactants} \quad \text{(Knowledge).}$$

$$= -26.4 - (-57.8) \text{ kcal} \quad \text{(Application).}$$

$$= 31.4 \text{ kcal}$$

$\Delta H_{reaction}$ is positive, therefore the reaction is endothermic and heat must be added. Conversion to water gas of 1 mol C requires 31.4 kcal. (Comprehension).

Conversion of 100 g C to water gas requires,

$$100 \text{ g C} \times \frac{31.4 \text{ kcal}}{12.0 \text{ g C}} = 261.7 \text{ kcal} \quad \text{(Analysis)}$$

The burning of carbon to carbon dioxide is represented by the equation:

$$C_{(s)} + O_{2(g)} \longrightarrow CO_{2(g)} \quad \text{(Comprehension)}$$

$$\Delta H_{reaction} = -94.1 \text{ kcal} \quad \text{(Knowledge)}$$

The sign of ΔH is negative which means that the reaction is exothermic and heat is evolved. (Comprehension).

The carbon burned to produce heat is not the same carbon that is used in water gas production. (Analysis).

Grams of C that must be burned to produce 261.7 kcal

$$= 261.7 \text{ kcal} \times \frac{12 \text{ g C}}{94.1 \text{ kcal}} = 33.4 \text{ g C} \quad \text{(Analysis)}$$

APPENDIX B

DATA ORGANIZATION

Appendix B

Correlation Matrices and Regression Analyses

A correlation matrix was run on the data collected on all enrollees. Because of the nature of the computer software used, some variables not intended for inclusion in the matrix had to be included. This inclusion did not effect the pertinent variables. The variables in the matrix were ID#, Sex, EI, SN, TF, JP, MBTI, %An, Prt, Fsc, Grd, Age, Instr, #An, Bnm, Anm, Dummy. On the next page is an explanation of the abbreviations used for the variables.

ID#, MBTI, Instr,and Dummy are variables that should have been omitted from the matrix since the individual values assigned had no serial relationship to the others. These four variables are therefore not included in the correlation matrix shown in Table B.1. The matrix was examined to determine which variables had the strongest correlation with final grade. Multiple regression was then applied to these using final grade as the dependent variable. The independent variables were Pretest, EI, SN, TF, and JP. SN was the only variable that was entered into the equation. The r squared value was 0.0198 and the r value was -0.1408. The results of the regression analysis are shown in Table B.2.

Abbreviation	Meaning
ID#	Student identification number.
Sex	Sex.
EI	Extroversion/introversion value.
SN	Sensing/intuition value.
TF	Thinking/feeling value.
JP	Judging/perception value.
MBTI	MBTI composite profile.
%An	% analysis questions correctly answered.
Prt	Pretest score.
Fsc	Final exam score.
Grd	Final grade.
Age	Age in years.
Inst	Instructor.
#An	Number of correctly answered analysis questions.
Bn	Number of nomenclature questions correctly answered in the second week of class.
Anm	Number of nomenclature questions correctly answered in the final week of class.
Dummy	A non-functional variable used as a space holder for a future variable.

The data was then sorted to exclude any students for whom Pretest scores had not been obtained. This reduced the sample from 159 to 120 students. A correlation matrix using the same 17 variables was run on the 120 student sample. In light of research question 2, multiple regressions were run using as independent variables, those variables which correlated most strongly with the dependent variable, Grade (final grade). The best results were obtained for the variables Prtst, SN, TF, and JP. The values of the correlation with grade were 0.326 for Pretest, -0.099 for SN, -0.110 for TF, and -0.114 for JP. The variables Pretest, SN, and JP were entered into the regression equation, TF was omitted. The r squared value was 0.1336, and the multiple r value was 0.3655. The results are displayed in Table B.3.

Table B.1

Correlation Matrix for All Enrollees

Number of cases = 159

	sex	EI	SN	TF	JP	%An	Prt	Fsc	Grd	Age	#An	Bnm	Anm
sex	1.0												
EI	.05	1.0											
SN	.07	-.1	1.0										
TF	.23	.06	.21	1.0									
JP	-.1	.02	.30	.29	1.0								
%An	.11	-.1	-.1	-.1	-.1	1.0							
Prt	-.04	-.1	.11	-.1	.01	.03	1.0						
Fsc	.09	-.04	-.1	-.1	-.01	.76	.14	1.0					
Grd	.10	-.1	-.1	-.1	-.1	.76	.10	.88	1.0				
Age	.05	-.02	-.01	.02	-.3	.06	.07	.02	.06	1.0			
#An	.14	-.1	-.1	-.1	-.03	.98	.03	.77	.76	.05	1.0		
Bnm	.04	-.1	.01	-.01	-.03	.50	.28	.40	.38	.03	.51	1.0	
Anm	.08	-.1	-.03	-.02	-.00	.34	.13	.32	.33	.01	.36	.54	1.0

Table B.2

Regression Analysis for All Enrollees

Number of cases = 159

Dependent Variable: Grade SN entered

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F Ratio
Regression	8.6	1	8.6	3.2
Residual	427	157	2.7	
Total	436	158		

Table B.3

Regression Analysis for All Who Took the Pretest

Number of cases = 120
Dependent Variable: Grade Pretest, SN, and JP entered

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F Ratio
Regression	44	3	15	6.0
Residual	286	116	2.5	
Total	330	119		

For further clarification, a data set containing only those students who took the Pretest and obtained a passing grade of "C" or better was created. It contained 63 students. A correlation matrix run on this data set showed that the strongest correlations with Grd were among the variables Prt with a value of 0.328, SN with a value of -0.205, TF with a value of -0.231, andJP with a value of -0.171. These variables were used in a multiple regression against Grd. Prt and SN were the only variables entered into the regression equation. The resultant r squared value was 0.1572, and the multiple r was 0.3964. The analysis Table is B.4.

Table B.4

Regression Analysis for "C" or Better Students

Number of cases = 63

Dependent Variable: Grade Pretest and SN entered

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F Ratio
Regression	5.2	2	2.6	5.6
Residual	28	60	.46	
Total	33.2	62		

In the same vein, a data set containing only those

students who took the Pretest and earned a "D" or "F" grade was created. There were 34 cases. A correlation matrix was run, followed by a multiple regression analysis. Both of these indicated a correlation between Grd and Prt, EI, SN, and TF. The value of the correlation with Grd was -0.162 for Prt, -0.379 for EI, -0.217 for SN, and -0.210 for TF. The multiple regression of Grd versus EI, SN and TF yielded an r squared value of 0.2138, and a multiple r of 0.4624. Table B.5 is the resultant ANOVA table.

Table B.5

Regression Analysis for "D" & "F" Students

Number of cases =34

Dependent Variable: Grade EI, SN, and TF entered

Analysis of Variance

Source	Sum of Squares	D.F.	Mean Square	F Ratio
Regression	1.7	3	0.55	2.7
Residual	6.1	30	0.20	
Total	7.8	33		

In response to research question 7, a data set consisting of students for whom final exam score was obtained was created. There were 116 cases. A multiple regression of EI, SN, TF, and JP against Fsc was run.

None of the variables met the criteria for entry into the regression equation.

Chi Square Statistics

Chi square analyses were performed on various data sets. One analysis tested the hypothesis that for grades "A" through "F" and "W", there is no difference in grades assigned by different instructors. A follow up analysis tested the hypothesis that for grades "A" through "F" and not including "W", there is no difference in grades assigned by different instructors. (Table 5.2). These analyses were necessary to answer research question 3. There are six different instructors for Chemistry 111 so it is important to determine if final grade is instructor dependent.

Chi square analyses for the sixteen MBTI profiles versus the various assigned final grades were performed in answer to research question 5 . (Table 5.2).

In response to research question 6, an analysis of the sixteen MBTI profiles against grouped final scores was performed. The final scores were grouped in percentage blocks that equate to letter grades. This was done to make the results more meaningful since actual scores are converted to letter grades in order to measure performance. The percentage groupings were as follows: 0 to 59%, 60 to 69%, 70 to 79%, 80 to 89%, and 90 to 100% which equated to

grades "F" through "A". (Table 5.2).

Frequency Distributions

Frequency distributions were used to explore hypotheses one, two, and three.(Tables 4.5 to 4.10).

Frequency distributions for the sixteen MBTI profiles were obtained. THe number of students distributed by grade, age, and sex were also obtained. The age distribution is shown in Table 3.1. Final grade distribution by MBTI profile was displayed in Table 4.1. There were 128 male and 31 female students.

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THE RELATIONSHIPS BETWEEN PROBLEM SOLVING STYLE AS MEASURED BY THE MYERS BRIGGS TYPE INDICATOR AND ACHIEVEMENT IN COLLEGE CHEMISTRY AT THE COMMUNITY COLLEGE

by
Fidele Lyn Alcorn

(ABSTRACT)

The purpose of this study was to examine the relationships between problem solving style as measured by the Myers Briggs Type Inventory (MBTI) and achievement in College Chemistry. It was postulated that preferences measured by the MBTI would increase the variance explained by the predictive tool currently in use. The sample population was taken from a suburban community college. It was found that problem solving style does increase the variance explained by the currently used predictive tool. There is a non-simplistic relationship between problem solving style as measured by the MBTI and achievement in College Chemistry. The problem solving characteristics of successful and unsuccessful students, as well as those who withdraw, were documented. Some of the relationships found were the same as those reported in MBTI literature; others were contrary to expectations based on the MBTI literature.