ABSTRACT

Title of Dissertation: THE INFLUENCE OF STUDENT AND TEACHER FIELD INDEPENDENCE/DEPENDENCE COGNITIVE STYLE ON STUDENT ACHIEVEMENT IN HIGH SCHOOL CHEMISTRY.

Thomas Alan Custer, Doctor of Education, 1994

Dissertation directed by: Dr. J. David Lockard, Professor Emeritus Botany and Science Teaching, Acting Chairman, Department of Botany.

The study examined the relationship between field dependence/independence of students and teachers on student achievement in high school chemistry as measured by the American Chemical Society's Test. The hypothesis was that differences in field dependent/field independent cognitive styles of students and teachers should not affect achievement in high school chemistry. Field independent learners are task oriented, set self-regulated goals, seek less guidance in problem solving and prefer to work individually. Field dependent learners are attuned to social interaction, favor structure, teacher direction and feedback and benefit from instruction in problem solving. Participants in the study were high school chemistry teachers and their 10th, 11th, and 12th grade general chemistry students enrolled in four public comprehensive high schools. The measures used to collect the data were the Embedded Figures Test (EFT) (Karp and Konstadt, 1971) and the American Chemical Society's High School Chemistry Test (ACS) (1991). The selected teachers represented extremes in field dependence/independence. Students of the selected teachers comprised the student group and totaled 272. Students were administered the EFT and ACS tests the first week of the second semester and teachers followed their typical instructional program. The ACS post test was administered to students during the last week of the semester. The basic design was two by two, field dependence/independence of students matched to field dependence/independence of teachers. Data analysis was conducted using the SPSS-X statistical package and included analysis of covariance. The covariant was the pretest results of the ACS test since the

students were not randomly assigned. The analysis of covariance indicated student scores on the ACS test were not significant when compared to field dependent/independent teachers and the null hypothesis was not rejected. The findings showed clearly that students with strong independent learning styles showed significantly higher chemistry achievement and greater achievement gains.

Further research needs to be conducted with a culturally diverse randomized student and teacher population, several reliable measures of chemistry achievement and data collection over a longer period of time.

THE INFLUENCE OF STUDENT AND TEACHER FIELD INDEPENDENCE/DEPENDENCE COGNITIVE STYLE ON STUDENT ACHIEVEMENT IN HIGH SCHOOL CHEMISTRY

by

Thomas Alan Custer

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Advisory Committee:

Dr. J. David Lockard, Chairman/Advisor
Dr. Donald Messersmith
Dr. John Layman
Dr. Steven Selden
Dr. Timothy Dangel

DEDICATION

To my wife, Clarice and our three daughters, Tommi, Julia, and Lee.

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There are not too many projects which get completed without the help of many friends and colleagues. This dissertation is no exception and is the result of support and encouragement from many people. My wife and daughters have been understanding and sacrificed considerable time to enable me to complete my studies and writing. I appreciate the guidance and patience of my advisor, Dr. Lockard and the suggestions and direction offered by Drs. Layman, Selden, Messersmith, and Dangel. Mary Bembe, my secretary, has done a fine job of keeping me on task completing the writing.

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CHAPTER 1

Introduction

Awareness of student differences and preferences for learning in different modalities continues to encourage research and impact instruction. Attempts to teach reading and writing through the auditory, visual, and kinesthetic modalities have been documented since pre-Christian Greece, according to Fernald (1943). Coop and Sigel (1971) noted that German psychologists discussed cognitive style at the turn of the century; Allport used the word style in his work of the 1930's; and Witkin, the "Father of Cognitive style," began his research in perceptual styles in the 1940's. Barbe and Milone (1981, p.78) stated that: "One of the most promising movements in contemporary education is the attention being given to student learning styles. The movement is based on the idea that students vary in their approach to learning, so . . . no single instructional process provides for all students."

Rationale

As today's schools look for ways to keep America competitive and increase student learning, the relationship between learning style and teaching style needs to be investigated. If America is to turn out world class students, teachers will need a body of research to utilize to increase student learning.

The background of this researcher as a chemistry instructor and his professional responsibilities to improve student achievement in chemistry, caused him to narrow the

research to studies which impact high school chemistry. Several studies provided the direction for this study.

Mitzel (1982) expressed the need to investigate several classes of variables and their relationship to chemistry achievement: (1) task variables (i.e., factors that affect a problem's difficulty, such as content), and (2) subject variables (i.e., student subject attributes that affect problem-solving achievement such as prior knowledge and cognitive style). Mitzel's paper stressed a need to analyze the evaluative instruments used for assessing student achievement.

Fails (1985) took the challenge from Mitzel and investigated the ability of chemistry students to solve problems as affected by field dependence/independence. The results indicated that field independent students were significantly better at solving chemical proportional problems than field dependent students. To determine field dependence/independence, the Find a Shape Puzzle (FASP) which was a version of the Embedded Figures Test, was administered.

A study done by Chandran, Treagrist and Tobin (1987) investigated the effects of a number of cognitive factors on chemistry achievement. The study involved eleventh grade Australian students from eleven high schools. The results indicated that field dependence/independence played no significant role in chemistry achievement. The researchers felt that further studies should consider the use of alternative measures of the variables. The study used the Hidden Figures Test (Educational Testing Service, 1966) for field dependence/independence and for achievement, three tests developed by Chandran were administered towards the end of the second semester. No pre-test results were administered to compare to the post-test results.

This study was developed to measure the effects of field dependence/independence and chemistry achievement. With a very reliable instrument to measure pretest and post test chemical achievement from the American Chemical Society, the researchers' request for evaluative instrument analysis was satisfied. Using the Embedded Figures Test from Educational Testing Services also met Chandran's and Fail's requirements for alternative measures of the field dependence/independence.

Significance

Research indicates that schools teach mainly to one style learner, the reflective thinker. However, McCarthy's (1981) studies indicated that reflective thinkers make up only 28-30% of the population, meaning that 70% of students are not getting the education best suited to their abilities. Dunn and Dunn (1975) stated that "most teachers can respond to differences in student learning styles.

In developing innovative educational programs, educators have considered a large number of different variables including students' intelligence, reading level, chronological age and interests. However, differences in information-processing skills, which are inherent among the individual students, are rarely considered. Because of this, changing an educational program might simply result in transferring students from one inappropriate experience to another. If educational programs are to be effective, it is essential that the students' learning styles are matched to instructional elements. Thus, knowledge of students' cognitive style takes on increased significance.

Over the last three decades, extensive research has been conducted on cognitive style. Witkin, Moore, Goodenough and Cox (1977) presented an excellent review of the research on cognitive style. While this review includes a discussion of educational implications, it does not provide evidence demonstrating the relevance of cognitive style to academic achievement. Some studies indicate a relationship between field-dependence-independence and intellectual functioning.

Goodenough and Karp (1961) and Witkin et al. (1974) found significant correlations between scores on field-dependence-independence and scores on the Stanford-Binet and WISC tests of intelligence. Coates (1975) and Goodenough and Karp (1961) found a common factor in tests of cognitive style in some WISC tests (Block Design and Geometric Design). Since academic skills overlap with intelligence, it is reasonable to suggest that there may be a relationship between cognitive style and academic performance. Thus, a better understanding of cognitive stylistic attributes that contribute to academic achievement would be useful to program developers, curriculum designers, textbook publishers, and teachers who want to improve instructional practices.

Purpose

The issue addressed in this research was the relationship between field dependence/field independence of students and teachers on student achievement in high school chemistry as measured by the American Chemical Society's test.

Key Questions

The research will concentrate on the relationship between field dependence/independence and academic performance in high school chemistry. It specifically examines the question:

> Is there a difference in high school chemistry achievement, as measured by the American Chemical Society's test, of field-dependent and field-independent students when taught by field-dependent/field-independent teachers?

Hypothesis

In any class of students, there will be differences in field dependent/field independent cognitive styles and these students will respond to instruction in a variety of ways. Differences in field dependent/field independent learning styles of students and teachers should not affect achievement in high school chemistry.

Definition of Terms

1. Learning style - in this paper, mainly directed to the modalities; the auditory, tactile, visual, and kinesthetic modalities, and items that influence these modalities.
2. Teaching style - a teacher's personal behaviors and the media used to transmit or receive data from the learner.
3. Cognitive style - the characteristic approach a person brings to a wide range of learning situations which encompasses both perceptual and intellectual activities.
4. Field-dependent individuals - learners who exhibit the following characteristics:

- are strongly interested in people;
- get closer to the person with whom they are interacting;
- have a sensitivity to others which helps them to acquire social skills;
- prefer occupations which require involvement with others;
- rely on the surrounding perceptual field;
- experience their environment in a relatively global fashion by confronting to the effects of the prevailing field or context;
- depend on authority;
- search for facial cues in those around them as a source of information.

5. Field-independent individuals - learners who exhibit the following characteristics:
   - are socially detached but have analytic skills;
   - prefer occupations that allow them to work by themselves;
   - can abstract an item from the surrounding field and solve problems that are presented and reorganized in different contexts;
   - experience an independence from authority which leads them to depend on their own standards and values;
   - are oriented towards active striving;
   - appear to be cold and distant.
6. Cognitive flexibility - the ability to function in the cognitive style required by the situation.

Key Concepts

The root disciplines which provide the basis for the study are cognitive psychology, knowledge utilization, and information processing.

Methodology

A measure of the field dependent/field independent learning style of students and teachers was administered at the start of the second semester. Students and teachers from four high schools with similarities in student populations (SES, size, racial make-up, etc.) were involved in the study. Classes were selected based upon the field dependent/field independent learning style of chemistry teachers. Teachers were administered the Embedded Figures Test (EFT, Karp and Konstadt, 1971) to determine their cognitive style, either field-independent/field dependent.. The results of the test were used to select four teachers at the extreme ends of the field dependent/field independent spectrum. Once the teachers were selected, (four total, two from each cognitive style) students in the chemistry classes of these teachers were administered the embedded figures test.

The dependent measure was the achievement test scores from the American Chemical Society. It was administered at the start of second semester to determine baseline knowledge. The ACS test was readministered at the end of the semester to measure achievement.

During the first semester the investigator practiced giving the EFT test and the ACS achievement test. Teachers selected for the study were given inservice training on how to administer both of the tests to students.

Measures

The measures to be used to collect the data were the Embedded Figures Test (Karp and Konstadt, 1971) and the American Chemical Society's Standardized Chemistry Test. The Embedded Figures Test (EFT) is a standardized test which measures individual perceptual differences among people as well as individual ways of cognitive functioning in a variety of settings. It is a widely accepted measure of cognitive style which distinguishes between field-dependent and field-independent persons, describing their cognitive functioning as analytical or global. Performance in the EFT indicates the individual's perceptual functioning in field-dependence-independence. The reliability estimates for EFT range from .83 to .90 (Karp and Konstadt, 1971).

The American Chemical Society's Standardized Chemistry Test is a standardized test to measure a student's knowledge of chemistry. It was used to measure the student's achievement in chemistry.

Procedures

To determine the students' cognitive style, the EFT was administered at the beginning of the second semester of a year course. Based on students' scores on the EFT, their cognitive style was characterized as field-dependent or field-independent. The American Chemical Society's test was administered for the first time in the first week of the second semester pre-instruction scores. At the end of the school year, the American Chemical Society's test was readministered to obtain post-instruction scores. Classroom instruction was not varied for field-dependent or field-independent students.

Design

The design of the study used the learning style as the independent variable and student achievement as the dependent variable. Pretest and post test scores allowed for analysis of covariance, employing the pre-ACS scores as a covariate.

Each teacher's cognitive style and professional background was identified. This information helped to describe subjects, but was not part of the analysis. The Embedded Figures Test was used to measure cognitive style and a questionnaire was developed to learn the professional backgrounds.

INDEPENDENT MEASURES

Cognitive Style

DEPENDENT MEASURES

Chemical Achievement

CHART 1

Research Design

TEACHER COGNITIVE STYLE	STUDENT COGNITIVE STYLE: FIELD-INDEPENDENT	STUDENT COGNITIVE STYLE: FIELD-DEPENDENT
FIELD-INDEPENDENT		
FIELD-DEPENDENT		

Limitations

1. The use of intact classes.
2. Selection of the American Chemical Society's test to measure chemistry achievement.

Delimitations

1. Limiting the study to Anne Arundel County Public Schools.
2. Using only chemistry students rather than all science students.

In Chapter two, the results of the literature search are listed and discussed.

CHAPTER 2

INTRODUCTION

One of the most promising movements in contemporary education is the attention being given to student learning styles. The movement is based on the idea that students vary in their approach to learning, so . . . no single instructional process provides optimal learning for all students (Bracht, 1970, p. 627 and p. 378). In a competitive world market where technology is a driving force, businesses are requiring higher standards for worker's education. These standards encompass a broader segment of jobs than has been the tradition. To fill the jobs will require a wider use of the work force, especially females and minorities. As national educational standards rise, science educators will find a diverse population of students sitting in chemistry classrooms traditionally occupied by above average ability or highly motivated children. As the population of children who select high school chemistry changes, the science education community must strive to meet the students' new and challenging needs. One viable answer to addressing the needs of a new group of students in chemistry classrooms across America may lie in a deeper exploration of the relationship of student learning styles to chemistry. This chapter will review the educational research on learning styles, the relationship between teacher learning style and student learning styles, and examine the research on the use of learning styles in understanding student success in the secondary school chemistry classroom.

LEARNING STYLES

A thorough examination of the literature of learning styles reveals a rich and booming history with most of the psychological and educational research studies in this area conducted within the last two decades. According to Guild (1980), the term "learning

style" was relatively new in the early 1970's, but by the end of the decade a significant number of studies and theoretical articles became available. ERIC computer search of the research published in 1975 on the term "learning styles" yielded less than 50 citations; in 1979, over 800 citations were submitted; in 1992, 1236 citations could be found. Prior to the 1970's a few researchers laid the foundation for the learning styles work of later years. Their work touched on the importance of considering sensory-motor development (Montessori, 1912; Kephart, 1960) and cognitive style (Coop and Sigel, 1971) in the learning process. Kephart (1960) reinforced Montessori's ideas that sensory motor activities were the basis for later academic and survival skills. Kephart felt that this held true for all children not just those with learning disabilities. He stressed that sensory motor or perceptual motor manipulation was necessary to allow the child to fit his behavior to the changing demands of the contemporary society. From this early consideration of the importance of cognitive style many researchers followed with a myriad of ideas and philosophies surrounding the impact learning styles have on the learning process of children and adults.

COGNITIVE STYLE AND LEARNING STYLE

The first issue that must be addressed is the multitude of definitions and conceptual frameworks the many learning styles researchers use in their work. Initially, it is important to address the use of the terms learning style and cognitive style. Brundage (1980) differentiates between the two in his work by reporting the following definitions. Cognitive styles are the consistent individual differences in the ways of organizing experiences into meanings, values, skills, and strategies. While learning styles are described as the consistent individual differences in the ways of changing meanings, values, skills, and strategies. Although Brundage delineates a difference in

meaning, most of the other researchers use the two terms interchangeably. For the purposes of this thesis the two terms will be understood to have similar meaning. However, the underlying understanding of the concept continues to vary greatly among researchers. Ewen (1978) provides us with her insight into cognitive style which is quite broad in scope. She states that cognitive styles, diverse ways of taking in information and processing it, usually developed by 12 years of age and remain rather stable over the years. A style has broad influence on aspects of personality and behavior, perception, memory, problem solving, interests, and career goals as well as social behavior (p. 9).

Witkin(1976), also believes in a pervasive definition as he describes cognitive styles as the form rather than the content of cognitive activity. Cognitive styles refer to individual differences in how we perceive, think, solve problems, learn, relate to others, etc. (p.15). Other researchers adopted a narrower view of the concept. Rosenberg (1968) states that learning styles refer to an individual's characteristic pattern of behavior when confronted with a problem. If a person is observed in a number of different problem-solving situations, a modal pattern of behavior can usually be ascertained. It is this modal pattern of his behavior that he refers to as his style (p. 22).

Similarly, Kogan (1971) defines learning style by saying that cognitive style can be most directly defined as individual variation in modes of perceiving, remembering, and thinking, or as distinctive ways of apprehending, storing, transforming, and utilizing information (p. 244).

Moreover, there are those researchers who seem to see the concept as a unique relationship between the person, his/her environment, and the process of learning. According to DeCecco (1968), learning styles are "personal ways in which individuals process information in the course of learning new concepts and principals" (p. 75). A decade later Taba, Levine, and Elzey (1964) defined learning style as the modes of thought which an individual employs rather persistently in the variety of different cognitive tasks, such as: selecting a basis for grouping objects, determining how to label what he sees and how to organize the various aspects of his environment (p. 8). Gregorc (1979) developed a definition of learning styles that says a learning style consists of distinctive behaviors which serve as indicators of how a person learns from and adapts to his environment. It also gives clues as to how a person's mind operates (p. 234).

Lastly, there are those who have described learning styles in terms of the student and achievement. Tallmadge and Shearer (1969) defined learning style as, "an attribute of an individual which interacts with instructional circumstances in such a way as to produce differential learning achievement as a function of these circumstances" (p. 222).

Along the same line Dunn, Dunn, and Price (1977) comment that, "how a student learns is perhaps the most important factor related to academic achievement, but relatively few instruments have been published that purport to diagnose those elements" (p. 419). They continue by stating that learning style is not the way you learn on a daily basis, but the way you are when you are really trying to learn something new.

Although researchers do not yet agree on a single definition, the concept of learning or cognitive styles is definitely thought by most to play an important role in a person's learning process. More than just a person's innate ability contributes to their overall ability to learn.

In 1980, Dunn offered five basic stimuli which he felt "affects a person's ability to absorb and retain...". They are environmental, emotional, psychological, physical, and sociological stimuli. Through each of these avenues people gather, collect, and assimilate information. The modes through which the information arrives have also come to be understood as intricate pieces of the learning styles puzzle. These modes, termed learning modalities, are that of the auditory, tactile, visual, and kinesthetic perception channels. The modalities most efficient in the processing of information for an individual are known as his/her modality strengths (Barb and Milone, p. 378). Barbe and Milone (1980) stated:

> Neither nature or nurture fully accounts for the development of a modality strength. Most likely, a person's heredity, maturation, learning, and cultural upbringing are all contributing factors. While sex and handedness have little impact on modality strengths, the influence of age is quite strong. Children in the early elementary grades have more well-defined strengths and they tend to be auditory rather than kinesthetic. As children progress through elementary school, their modalities become mixed and interdependent and shift decidedly toward the visual and kinesthetic. By adulthood, many people have mixed modality

> strength. Children with mixed modality strengths seem to have an advantage in the classroom. Though they are no more or less intelligent than students with a single strength, they are able to process information efficiently no matter how it is presented. The other students learn much more easily when they are taught through their particular modality strengths (p. 45).

As their work progressed Barbe and Milone (1981) refined their understandings of the contributions of learning modalities to learning and produced the following seven statements on modality strengths:

1. Students vary with respect to their modality strengths.
2. Modality strength is not a fixed characteristic.
3. Modalities become more integrated with age.
4. There is no clear difference between modality characteristics of boys and girls.
5. Handedness and modality strengths do not seem to be related.
6. Race and modality strengths were independent.
7. There is an interaction between student and teacher modality strengths (pp. 378-379).

From their findings Barbe and Milone (1981) strongly concluded that student modality strengths should be considered in instructional planning, including selecting or developing media and materials as well as in the design of the physical learning environment. Many of the learning style researchers agreed with Barbe and Milone

regarding the important role of learning modalities, however, they were at odds to the modalities' developmental order of importance. Contrary to the findings of Barbe and Milone, Carbo (1980) and Price (1980) found the visual and kinesthetic channels of perception to be very strong in young children. According to Price (1980), young children appear to learn more easily when taught through tactile/kinesthetic methods; those preferences evolve into visual strengths as they mature at different rates.

Most, however, do not develop the ability to learn and remember well through their auditory sense until the intermediate-elementary years. In a reading study conducted by Carbo in 1980, statistically significant results were found when reading treatments were matched to children's modality strengths. Moreover, Burton (1980) found that when treatments were not matched with modalities, visual methods were more successful with primary children than auditory approaches despite the fact that the youngsters had been taught phonetically. Further evidence surfaced to support the strength of the visual modality through the dissertation work of Urbschat (1977). Her research, which included 135 first grade students, found that modality strengths can be identified among first graders; superior and significant results occurred when a treatment was matched to the appropriate modality; and most of the first graders in the study found it easier to learn through either a visual or a combination of auditory/visual treatment rather than solely through an auditory approach. Regardless of the child's modality strength, a treatment that included a visual approach achieved significance with auditory, visual, and auditory/visual children. No one modality evidenced superiority.

Dunn (1980) cited, the studies of Carbo, Burton, Urbschat, and Price listed above, and their implications for reading instruction recommend that:

1. Reading treatments should match individual student's existing current perceptual strengths.
2. For non-auditory learners, beginning reading should be taught through tactile/kinesthetic resources that are strongly interfaced with visuals (p. 1).

TYPES OF LEARNING STYLES

As is it important to understand the many channels or modes through which humans receive information, so too is it important to realize the depth and complexity of what happens to the information once it reaches the learned. Learning modalities is but the first step in the stairs of the learning styles paradigm. Continuing onward reveals a web of issues that some researchers have termed the types of learning styles. Kogan includes Samuel Messick's (1976) cognitive styles in his discussion of the various types of learning styles. Messick and Kogan have identified nine types of learning styles:

1. Field independence vs. field dependence: an analytical, in contrast to a global, way of perceiving (which) entails a tendency to experience items as discrete from their backgrounds and reflects ability to overcome the influence of an embedding context.

2. Scanning: a dimension of individual differences in the extensiveness and intensity of attention deployment, leading

to individual variations in the vividness of experience and the span of awareness.

3. Breadth of categorizing: consistent preferences for broad inclusiveness, as opposed to narrow exclusiveness, in establishing the acceptable range for specified categories.

4. Conceptualizing styles: individual differences in the tendency to categorize perceived similarities and differences among stimuli in terms of many differentiated concepts, which is a dimension called conceptual differentiation, as well as consistencies in the utilization of particular conceptualizing approaches as bases for forming concepts (such as the routine use of concept formation of thematic or functional relations among stimuli as opposed to the analysis of descriptive attributes or the inference of class membership).

5. Cognitive complexity vs. simplicity: individual differences in the tendency to construe the world, and particularly the world of social behavior, in a multi-dimensional and discriminating way.

6. Reflectiveness vs. impulsivity: individual consistencies in the speed with which hypotheses are selected and

information processed, with impulsive subjects tending to offer the first answer that occurs to them, even though it is frequently incorrect, and reflective subjects tending to ponder various possibilities before deciding.

7. Leveling vs. sharpening: reliable individual variations in assimilation in memory. Subjects at the leveling extreme tend to blur similar memories and to merge perceived objects or events with similar but not identical events recalled from previous experience. Sharpeners, at the other extreme, are less prone to confuse similar objects and, by contrast, may even judge the present to be less similar to the past than is actually the case.

8. Constricted vs. flexible control: individual differences in susceptibility to distraction and cognitive interference.

9. Tolerance for incongruous or unrealistic experiences: a dimension of differential willingness to accept perceptions at variance with conventional experience. (Messick in p. 246)

Riechmann and Grasha (1974) presented another type of learning style. Grasha-Riechmann Student Learning Style Scales, were developed to assess and distinguish six student learning styles based on the types of learning styles students demonstrate in the classroom. Grasha-Riechmann describe six types of learning style. They are:

1. Independent. This response style is characteristic of the student who likes to think for himself. He prefers to work on his own . . .

2. Dependent. This style is characteristic of the student who shows little intellectual curiosity and who learns only what is required. She sees teachers and peers as sources of structure and support ...

3. Collaborative. This style is typical of the student who feels he can learn the most by sharing his ideas and talents . . .

4. Competitive. This response style is exhibited by the student who learns material in order to perform better than others in the class...

5. Participant. This style is characteristic of the student who wants to learn course content and likes to go to class. She takes responsibility for getting the most out of class . . .

6. Avoidant. This response style is typical of a student who is not interested in learning course content in the traditional classroom. He does not participate with students and teachers in the classroom . . . (pp. 221-222).

Clearly the nine types of learning styles of Messick and Kogan and the six of Riechmann and Grasha differ greatly in focus, context, and scope. Messick and Kogan concentrate on the detail of the learning and internalizing information, while Riechmann and Grasha summarize observable student behavior while information processing takes place. Together, the two lists begin to add depth to the concept of learning styles.

COGNITIVE STYLE MAPPING

The research of three other prominent learning theorists, Hill, Kolb, and Witkin, also greatly adds to the total understanding and importance of learning styles. Dr. Joseph E. Hill, president of Oakland Community College, in Bloomfield Hills, Michigan, created a structure called the Educational Sciences while studying cognitive style mapping. The program was used to a limited extent at Wayne State University in an adult education program and on a wide-spread basis at Oakland Community College. In developing the structure called the Educational Sciences, Hill makes certain assumptions. They are:

1. Education is the process of searching for meaning.
2. Thought is different from language.
3. Man is a social creature with a unique capacity for deriving meaning from his environment and personal experiences through the creation and use of symbols.
4. Not content with biological satisfactions alone, man continually seeks meaning (Hill and Nunnery on p. 75).

In order to understand cognitive style mapping, one must understand the seven sciences

and their structures as proposed by Hill. The first science is concerned with symbols and their meanings. According to Neil (1975), the first science's primary assumptions are its primary assumptions are that humankind uses two kinds of symbols - theoretical and qualitative, and that these symbols are basic to the acquisition of knowledge and meaning (p. 75). The second science is concerned with cultural determinants of the meanings of symbols. "It centers on the cultural influences that affect what symbols mean to particular individuals" (p. 76). Neil comments that tests will unveil students preferences for studying alone or with peers as well as the relationship of problem solving and priority setting based on family values and cultural differences.

The third science is a form of inference. This is the form of inference a person tends to use. Neil states that a student may use categorical reasoning, reason by comparison and contrast, synthesize a number of components into a related unity, or employ all of these processes to appraise the situation and draw a conclusion (p. 76). The fourth science is that of memory-concern. According to Neil short- and long-term memory functions and their relationship to energy and biochemical elements are exceedingly complex. The memory processes of recognition, retention, recall, and association are identified in the testing process by the "concern" components relating to persons, processes, and properties (p. 76). The fifth science is cognitive style. This is the individual's preferred learning style. Neil reports the fifth science is the product of the first four sciences . . . the consistency and pattern of expressive behaviors (p. 76). The sixth science proposed by Neil is teaching, counseling, and administrative style. Neil provides that each of these styles is represented as a product of three sets of information pertaining to demeanor, emphasis, and symbolic orientation (p. 77). The seventh science is call systemic analysis

decision making. This is an educational systems theory. Neil outlines that basic to the system is the statement of goal or mission, which includes specific performance criteria and determines inputs. The outputs are measurements of how well the results fulfill the mission. The educational process requires much human feedback, communication, and modification or revision in order to keep the system adjusted (p. 77). In the use of the Hill model, students are provided with a computer printout which "maps" their cognitive traits and provides a description of their particular cognitive style. This information is obtained from inventories and standardized tests which measure preferences. Five documents were uncovered that were related to or used the Hill model of cognitive mapping. A paper written by Griffin entitled, "Cognitive Style: A Science to Influence the Policy of Individualizing Instruction," discussed the use of three of the Educational Sciences - symbolic orientation, cultural determinants, and modalities of inference, to discover the learning style of students at Central Piedmont Community College. Thirty-three freshman developmental students at Piedmont were tested to determine their learning styles. The document demonstrates that the conceptual framework for determining learning styles exists in the theory of Educational Sciences developed by Hill. Heun (1975) and others report on "Maximizing Individual Student Learning Through Cognitive Style Mapping." The authors report that mapping the cognitive style of individual learners is one attempt to gain more precision and accountability in solving learning problems in education. . . . Cognitive Style Mapping is a diagnostic procedure . . in that it is designed to determine how a person derives meaning from the world around him, specifically how an individual encodes, processes and decodes meanings (p. 1). Heun, Heun, and Ratcliffe (1975) emphasize the edumetric uses of the cognitive style map instrument. They state that the Cognitive Style Map Instrument is primarily designed

for edumetric uses rather than psychometric uses. It is designed to measure the gain or growth of an individual's knowledge, learning skills or abilities (comparing him with himself) rather than measuring individual differences in relation to a group (comparing him to others) (p. 1). Cognitive Style Mapping and Matching Reading Program Alternatives" is discussed in a paper sponsored by the Niagara Falls Board of Education under the sponsorship of the Office of Education (DHEW), Washington, D.C. Cognitive style mapping enables adult basic education (ABE) teachers to more readily identify a student's cognitive style, or preferred way of acquiring information, as well as the specific areas where improvement is needed (p. 1).

The second prominent learning theorist prevalent in the literature is Kolb whose work is based on Lewin's cycle of experiential learning. Kolb's experiential learning theory is so called because the term has its historical origins in the social psychology of Lewin of the 1940's as well as the sensitivity training of the 1950's. The emphasis (Kolb, 1976, p. 235) is on the role that experience plays in the learning process, an emphasis that differentiates this approach from that of other cognitive style theorists. A description of the model is presented by Williams (1980):

> . . . he conceptualizes learning as a four-stage process. The first stage, concrete experience, is followed by observations and reflections. This leads on to the formation of abstract concepts and generalizations which should be followed by testing the implications of concepts in new situations. This then leads into a further cycle of new experiences and so on (p. 389).

Kolb (1976) describes his own work as follows:

> The experiential learning model represents an integration of many of the intensive lines of research on cognitive development and cognitive style. The result is a model of the learning process that is consistent with the structure of human cognition and the stages of human growth and development. It conceptualizes the learning process in such a way that differences in individual learning styles and corresponding learning environments can be identified (p. 235).

From his work on the experiential learning model Kolb (1976) developed the Learning Style Inventory (LSI), an instrument designed to measure individual learning styles. One study which used the Kolb model and LSI was conducted by Hunter and McCants (1976) at Sinclair Community College in Dayton, Ohio. Through studying students' preferred learning styles they found older students showed a preference for a structured environment stressing organization and detailed instructions, while younger students preferred peer and teacher affiliation in the learning environment. The individual's emphasis on four learning abilities are particularly measured by the Learning Style Inventory as shown in Table A.

TABLE A

KOLB'S LEARNING STYLE INVENTORY: MEASURED LEARNING ABILITIES	
LEARNING ABILITIES	CODE
Concrete Experience	CE
Reflective Observation	RO
Abstract Conceptualization	AC
Active Experimentation	AE
Abstract over Concrete*	AC-CE
Action over Reflection**	AE-RO

* degree to which individual emphasizes abstractness over concreteness

** degree to which individual emphasizes action over reflective observation

Kolb emphasizes that socialization experiences, both past life experiences and present experiences, resulting from the demands of the environment aid in the development of a learning style. The Learning Style Inventory measures the individual's strengths and weaknesses as a learner. Kolb describes these styles as Converger, Diverger, Assimilator, and Accommodator. Kolb describes these four styles using the following descriptions. Convergers' dominant learning abilities are Abstract Conceptualization and Active Experimentation. "Their greatest strength lies in the practical application of ideas . . . persons with this style . . . do best in those situations, like conventional intelligence tests . . . these persons organize knowledge in such a way that . . . they can focus it on specific problems . . . they tend to have narrow interests and often choose to specialize in the physical sciences" (p. 238).

Divergers are best at Concrete Experience and Reflective Observation. Their greatest strength lies in imaginative ability. They excel in the ability to view concrete situations from many perspectives and to organize many relationships into a meaningful "gestalt." . . . persons of this type perform better in situations that call for generation of ideas, such as "brainstorming" sessions. Divergers are interested in people and tend to be imaginative and emotional . . . Counselors, organization development consultants, and personnel managers often have this learning style (p. 238).

Assimilators' dominant learning abilities are Abstract Conceptualization and Reflective Observation. Their greatest strength lies in the ability to create theoretical models. They excel in inductive reasoning, in assimilating disparate observations. . . . They are less interested in people and more concerned with abstract concepts, but less concerned with the practical use of theories . . . this learning style is more characteristic of the basic sciences and mathematics than of the applied sciences (p. 238).

Finally, Kolb describes an Accommodator as one who is best at Concrete Experience and Active Experimentation. Their greatest strength lies in doing things . . . and becoming involved in new experiences. They tend to be risk takers . . . persons with this style tend to excel in situations that call for adaptation to specific immediate circumstances. . . . They tend to solve problems in an intuitive trial-and-error manner . . . Accommodators are at ease with people but are sometimes seen as impatient and "pushy." Their educational backgrounds are often in technical or practical fields such as business. . . . people with this learning style are found in "action-oriented" jobs, often in marketing or sales (p. 238).

Third, and most important to this thesis, is a model of a type of learning style researched by Witkin and others known as Field-Independence vs. Field Dependence. This cognitive style is probably the best known of all the styles discussed in this review of the literature. Support of this statement is given by Kogan as he states, "Of all the cognitive styles under consideration...the field-independence-dependence dimension is unquestionably the most widely known and thoroughly researched" (p. 247). As this learning style is the basis of argument for this study, it will be discussed in detail in the following section.

FIELD-INDEPENDENCE vs. FIELD-DEPENDENCE

Witkin and others (1981) stress the importance of field-independence vs. field-dependence in the learning process when they report that among the cognitive styles identified to date, the field-dependence-independence dimension has been the most extensively studied and has had the widest application to educational problems (p. 1). Witkin and associates use three tests to " . . . ascertain the extent to which the surrounding visual framework dominates perception of an item within it" (p. 41). The first test requires the subject to align a rod with a surrounding frame; the second test uses the subject's body as the object of perception, using a room and chair to be tilted clockwise or counterclockwise, together or independently. The third test is one involving figures. A figure is shown, removed, and must be located in a complex, organized field. A person's cognitive style is determined from his or her performance on one of these three tests. Witkin and others report that each of the three situations produces a quantitative indicator of the extent to which the subject's perception of an item has been influenced by the organized field surrounding it. In these three tests of

field dependence versus independence, a more field-independent style is associated with greater accuracy . . . . people tend to be self-consistent in performance across these three tasks (p. 41). Witkin sheds additional insight on this subject by suggesting that the common denominator underlying individual differences in performance in these various tasks is the extent to which the person perceives part of a field as discrete from the surrounding field as a whole, rather than embedded in the field; . . the extent to which the person perceives analytically (p. 7). Some of the most significant findings from the research conducted by Witkin and others (1981) on the field-independent vs. field-dependent cognitive styles are outlined below:

- Women tend to be more field dependent than men on the average. However, this differs in some societies, thus pinpointing the importance of the role of socialization in the development of sex differences in field-dependence-independence.

- The styles that are first identified in perception tend to transfer to the problem solving domain. A person who is unable to separate an item from the surrounding field (field-dependent individual) is likely to have trouble with problems which require taking a critical element out of context in order to arrive at a solution.

- Field-independent persons tend to impose structure on stimulus material which lacks structure. Ordinarily, field-dependent persons leave the material "as is".

- Field-dependent individuals, in contrast to those who are more field-independent, are attentive to and "tuned" to the social components of the environment. The thoughts and feelings of others are determined from people's faces as read by the field-dependent person. An interest in what people say and do and being sensitive to social clues is more characteristic of the field-dependent person.

- Field-dependent individuals like people to be close to them, and are generally drawn to people in the way they use interpersonal space.

- There is a tendency for the field-independent person to show more nonverbal behavior than the field-dependent individual.

- Field-independent persons tend to exhibit a more impersonal orientation. They are more interested in the abstract and the theoretical.

- There is a tendency among field-dependent persons to select vocations in which they are involved with others and subject-matter which features human content. Solitary work environments and abstract subject matter are more often selected by the field-independent individual.

- Field-independent persons are more likely to be aware of their own needs and feelings as opposed to those of others. These needs and feelings provide an internal frame of reference used by field-independent persons as they deal with external social referents.

- Field-dependent people tend not to define social roles as distinct from the roles of those with whom they interact.

- The relatively field-dependent person tends to experience the body as having limits and boundaries, whereas field-independent individuals have a more global concept of the body.

- Specialized defenses and intellectualization are more often used by field-independent persons, whereas repression would be a defense favored by the field-dependent person. (Witkin, pp. 7-14).

Thus, field dependent and field independent learners tend to be at opposite ends of the learning spectrum. Saracho and Spodek (1981) provide a comparison of these bipolar characteristics. Field dependent learners have the following characteristics:

- rely on the surrounding perceptual field;

- experience their environment in a relatively global fashion by confronting to the effects of the prevailing field or context;
- depend on authority;
- search for facial cues in those around them as a source of information;
- are strongly interested in people;
- get closer to the person with whom they are interacting;
- have a sensitivity to others which helps them to acquire social skills;
- prefer occupations which require involvement with others.

In contrast, field independent persons:

- perceive objects as separate from the field;
- can abstract an item from the surrounding field and solve problems that are presented and reorganized in different contexts;
- experience an independence from authority which leads them to depend on their own standards and values;
- are oriented towards active striving;
- appear to be cold and distant;
- are socially detached but have analytic skills;
- prefer occupations that allow them to work by themselves (p. 154).

Psychological differentiation assists individuals to cope with aspects which are discreet from their context so that they are able to reorganize them. A field independent individual is better able to reorganize them. A field independent individual is better able to reorganize, restructure, and process information than a field dependent individual.

The degree of differentiation in how information is processed reflects the individual's social and intellectual behaviors. Field independent individuals perceive themselves as distinct from their social environment more than do field dependent individuals. Field independent individuals exhibit greater cognitive competence, while field dependent individuals are more socially competent. Thus, field dependent individuals are more sensitive to the feelings of others, while field independent individuals are more socially detached (Witkin, Dyk, Faterson, Goodenough, and Karp, 1974; Witkin and Goodenough, 1981).

Through all of this work by Witkin et al (1974, 1981) it is clear there are observable, detectable, and measurable differences between people with respect to their dependence on the field of learning for the personal gathering and processing of information. This being the case, the learning theorist is led to ponder the questions: How can this knowledge of field-independence vs. field dependence be used in the instructional arena of school? How can this knowledge play a role in assisting teachers in facilitating the learning of students? Is it possible that attempting to match teacher and student learning styles could yield positive students achievement results within a school setting? These important questions are the foundation for issues addressed within the next section.

RELATIONSHIP OF TEACHER TO STUDENT LEARNING STYLES

The field dependent-independent dimension of learning styles relates to how teachers teach, how students learn, and how teachers and students interact. Field dependent teachers prefer instructional strategies which require a great deal of interaction among individuals; whereas field independent teachers prefer informal instructional strategies which emphasizes cognitive elements (Witkin, Moore, Goodenough, and Cox, 1977). According to Saracho (1983), several styles interact in educational settings, and a number of interactions between children and teachers take place in a classroom. Researchers have suggested matching achievement styles to instructional environments (Ross, 1980), matching students' cognitive responses to teaching skills (Winnie and Marx, 1980), and matching students' preferences to the teaching style (Reiff, 1982). Researchers usually examine teaching styles by exploring the teachers' and students' perceptions of each other. Witkin, Moore, Goodenough, and Cox (1977) reviewed the relationship of teaching style to teachers' cognitive style. Field dependent teachers favored a warm and personal learning milieu and involved students in establishing goals and guiding their learning. Conversely, field independent teachers strived to express the cognitive aspects of teaching and preferred to organize and direct the learning. While field dependent teachers tend to employ discussion methods, field independent teachers utilize more lecture methods. Wu (1968) supports the idea that field dependent teachers favor greater interaction with their students, whereas field independent teachers favor teaching situations that are impersonal in nature and oriented toward more abstract cognitive aspects of instruction. In a study by Moore (1973), field dependent teachers employed questions primarily in evaluating pupils' learning and after the instructional phase was finished. Emmerich, Oltman, and McDonald (cited in Witkin et al., 1977)

concluded that field dependent teachers favored class discussion over teacher lectures as a technique to enhance pupils' learning. In addition, as compared with field independent teachers, field dependent teachers more greatly favored high student involvement in structuring the learning activity as a teaching strategy. Field independent teachers employed questions as instructional tools more frequently than did field dependent teachers as they introduced new units and responded to students' answers. Reinforcement also varied based on the teachers' cognitive style. Field independent teachers were found to more greatly favor feedback indicating errors (negative assessment) and explaining the underlying error to promote learning.

Ekstrom (1976) examined the relationship between certain cognitive and attitudinal characteristics and the instructional mode of elementary school teachers. At both second- and fifth-grade levels, few of the teacher scores indicated a consistent relationship to any teaching behavior exhibited in either reading or mathematics instruction. Field dependent teachers were more concerned with behavioral control in the classroom than were field independent teachers. In addition, field dependent and field independent teachers viewed the requirements for the grades and subject areas differently. Teachers did not perceive training as a homogeneous task but chose different teaching styles based on their perceptions of the demands of the instructional task. Cognitive flexibility in teachers permits them to employ several organizational techniques (such as using aides, various groupings, etc.) to provide individual instruction. An understanding of cognitive style can aid teachers in broadening teaching methods and curricula to accommodate more student's preferred cognitive styles (Neill, 1990).

Mahlios (1981) found that approaches used in classroom teaching relate to teachers' cognitive styles, although observations of teachers' approaches did not indicate the way teachers differ in meeting students' learning styles. Specifically, Mahlios investigated the differences in teaching preferences and instructional approaches between field dependent and field independent teachers observed under special research conditions, attempting to determine whether such differences are representative of cognitive style differences in actual classroom teaching. He examined (a) the frequency and context of instruction (whole groups versus small groups and individual students), (b) the function of questions teachers ask children, and (c) the frequency and kind of corrective feedback teachers use. Field dependent teachers interacted significantly more often with their pupils in small groups and individually, whereas field independent teachers initiated a significantly greater number of academic interactions with their pupils as a whole class. Mahlios (1981) also found that field dependent teachers asked more factual questions, whereas field independent teachers asked more analytic level questions. In addition, field independent teachers asked more academic questions than did their field dependent peers. Thus, field dependent teachers preferred to encourage pupils to apply principles. Field independent teachers also yielded more corrective feedback statements after pupils' failures and conceptually elaborated and extended their feedback after pupils' successful statements. Apparently, field dependent and field independent teachers vary in their academic interactions, in the context of their interactions with pupils, in the conceptual level of instructional activity, and in the type of feedback they give their students.

STUDENTS LEARNING STYLE

The teaching-learning process differs between field dependent and field independent persons. As examples, field dependent students seem to better learn and remember incidental social stimuli (Eagle, Goldberger, and Breitman, 1969), can be influenced with external reinforcements such as praise or criticism (Konstadt and Forman, 1965), and encounter difficulty with relatively unstructured materials (Renzi, 1974) as compared with field independent individuals. Perhaps both field dependent and field independent students learn better when the concepts, and content are consistent with their cognitive style (Saracho, 1988). Teaching style can have a tremendous impact on the learner in connection with the learner's cognitive style. Teaching style consists of a teacher's personal behaviors and the media used to transmit to or receive data from the learner. Teacher behaviors and media use place demands upon both the teacher and the learner to align their styles (Practical Applications of Research, 1980, p. 1). Although it is recognized that a myriad of learning styles exist across a population of students and teachers, in general, research indicates that schools teach mainly to one style learner, the reflective thinker. McCarthy's (1981) studies indicated that reflective thinkers make up only about 28-30% of the population, meaning that 70% of our students are not getting the education best suited to their abilities. Kuchinskas (1979) suggested that, rather than instruction being adapted to how students learn, it presently is reflective of each teacher's own person cognitive style. She asserted that unless the cognitive style of the teacher compliments that of the student, learning is less likely to occur. In support of her argument other researchers have shown similar findings. In 1979, the work of Trautman examined student achievement in knowledge, comprehension, and application when instructional materials were matched and mismatched to identified learning style.

Trautman found that whenever the instructional materials were matched correctly to the student's identified style, statistically significant academic gains were made, and whenever the materials and styles were mismatched, achievement fell below that of both matched groups.

Fischer and Fischer (1979) stated that different instructional problems arise and different outcomes are achieved depending on the combinations (of learning styles/teaching styles) found in various classrooms. This is consistent with the analysis of Kagan (1963) who concluded, "new pedagogical procedures should acknowledge the interactions between the dispositions of the learner and the material, and tailor presentations to the preferred strategy of the child" (p. 323).

Fischer and Fischer make the assumption that most human beings can be changed, and therefore, to some extent at least, both learning and teaching styles can be modified. They also believe that as professionals, teachers must be willing to examine and to alter their teaching styles if evidence of judgment of other professionals warrants such change. "Such change must always be guided by the key consideration: Will this change help or hinder the learner in developing toward autonomy?" (Fischer and Fischer, 1979, p. 254).

McCarthy (1979) measured the cognitive and affective progress of students whose learning style preferences were matched to special formats designed to enhance them and compared the results with the progress of students who were not matched. The results indicated that matched students' progress in cognitive variables was significantly better than nonmatched students. Dunn and Dunn (1975) stated that "most teachers can respond

to differences in student learning styles . . . That is preferable to trying to match students with teachers" (p. 238). The Dunns continued by strongly stating that learning style and teaching style characteristics do not always cluster into such neat packages; students are not consistently one way or the other - nor are teachers; neither traditional nor informal teachers are necessarily excellent . . . and given the practical, "how-to" skills for teaching students through their individual learning styles, most teachers can become effective with most students (p. 244). Dunn and Dunn do stress, however, that "the closer the teaching style and learning style are matched, the higher the grade point average, consistently." Finally, in a 1980 study by Cafferty the match of cognitive styles and complimentary methods were shown to cause increased achievement where as the mismatch resulted in the reverse. Conversely, there are researchers who do not view the matching of teacher and learner cognitive styles to be of paramount importance and offer the suggestion that the matching, in some cases, may in fact be a hindrance to learning growth. Saylor and Alexander (1974) stated that different procedures and methods will need to be used with different students for the attainment of educational goals, but regardless of his abilities and learning styles these efforts to personalize instruction should never deny a student the whole range of opportunities for the fullest measure of development of his unique potentialities (p. 281).

Turner (1979) felt that the virtue of schools is that students experience a variety of teaching styles. A key feature of virtually all school organizations is that little effort is made to control the variability of teaching styles and learning styles. Schools rarely attempt to match the styles of learners to styles of teachers. Therein lies much of the strength and durability of the school as a social entity (p. 257). Along the same line,

Ellis (1979) wrote that instead of attempting to make matches between teaching and learning styles, we (the teachers of Parkway School) are recognizing and capitalizing on the variety of styles that teachers possess and that they can acquire. We are trying to provide the children of Parkway School with a variety of learning environments that will be responsive to their individual learning styles (p. 277). It is along this line of flexibility that many studies continued to be designed and conducted.

In 1979, Gregorc concluded from a review of many learning styles studies that teaching style is much more than a methodology. It places subjective demands upon the learner who may or may not have abilities to match such demands (p. 236). Hence, some educators suggested that it is important not only to identify (and perhaps consider matching) cognitive styles, but also to be able to modify them in order to help teachers and students employ the characteristics of both field-dependence and field-independence. Cognitive flexibility, the degree that individuals are able to vary their information processing techniques in relation to specific activities, has been proposed as an educational goal by researchers (e.g., Battig, 1979; Davis and Cochran, 1982; Davis and Frank, 1979; Macleod, 1979; Ramirez and Castaneda, 1974; Saracho and Spodek, 1981). However, it is uncertain whether such modification can be achieved. Some researchers indicate that field independent persons have more flexibility in selecting effective strategies in a range of activities. Kogan (1971), for example, believes that field dependent individuals are more resistant to cognitive style modification than are field independent individuals. The difference between field dependent and field independent students could possibly relate to the wider range of alternative opportunities they receive, to their willingness to use a variety of techniques, and/or to their ability to become aware that a specific strategy is not effective. Information-processing systems

may differ according to individuals' cognitive flexibility and depending on their ability to function using the characteristics of the cognitive style that is required for the particular task activity. The issue of modifiability of cognitive style is important because of its implications for facilitating or stifling learning. It is possible for a specific style to be maladaptive in a particular instructional context but valuable in other contexts. For instance, a teacher may plan a mathematics lesson, considered to be a field independent activity, for a field dependent child. This child will have difficulty with formal instruction in mathematics and will probably learn the concept better through a social activity, such as dramatic play. In order for this child to be able to learn mathematics in an abstract mode, his or her cognitive style would need to be modified to ensure adequate functioning in a field independent way. On the other hand, the field independent child can easily perform cognitive problem-solving tasks but may be deficient in performing tasks involving social sensitivity, interpersonal harmony, and other important affective skills.

Kogan (1971) suggests a guiding question for those interested in modifying cognitive functioning: Will the change enhance the individual's cognitive flexibility? One desirable goal of such modification is to assist individuals to acquire the capacity to shift their cognitive approach based on changing task requirements. Individuals who have become "locked" into a customarily adaptive manner of cognition may find that their usual approach can be harmful when applied to certain tasks. In attempting to enhance anyone's cognitive flexibility, it is important to consider whether the modification will actually alter functioning in a way that will allow the individual to deliberately choose a style of cognition rather than be compelled to approach a given problem in a specific way. It is also important to consider whether, as a result of heredity, personal constitution, or

early experiences, some styles are profoundly inherent in some persons and thus cannot be changed. Friedman and Alley (1984) suggest that instructors tend to employ teaching methods that fit their learning styles rather than the styles of their students. However, Matthews (1991) found that accommodations made by instructors assisted students in expanding their repertoire of styles and their school performance was strengthened. Research supports a classroom environment that accommodates preferred cognitive styles of students (Dunn, Beaudry, and Klavas, 1989).

LEARNING STYLES AND STUDENT ACHIEVEMENT IN SECONDARY CHEMISTRY

Cognitive styles of both teacher and student alike can be measured and have been shown by many researchers to play an important role in the learning process. This knowledge could prove extremely useful within the teaching and learning of general high school chemistry. The high school chemistry course is most often the first time children experience a class where the primary focus of the course is problem solving with a strong emphasis on mathematical use and reasoning. Students are challenged from the basics of recall and recognition of simple element symbols and formulas to the abstract reasoning and analytical thinking of solving complex stoichiometric problems and grasping the science concepts behind intricate laboratory experiments. Their abilities, cognitive strategies, and learning styles are all challenged in this new learning arena. With the many variables present in the chemistry classroom learning environment, many researchers have shown an interest in this milieu. Mitzel (1982) expressed the need to investigate several classes of variables and the relationship to chemistry

achievement: (1) task variables (i.e., factors that affect a problem's difficulty, such as content), and (2) subject variables (i.e., student subject attributes that affect problem-solving achievement such as prior knowledge and cognitive style. Mitzel's paper stressed a need to analyze the evaluative instruments used for assessing student achievement. Fails (1985) continued the challenge posed by Mitzel and investigated the ability of chemistry students to solve problems as affected by field dependence/independence. To determine field dependence/independence, the Find a Shape Puzzle (FASP) which was a version of the Embedded Figures Test, was administered. The results indicated that field independent students were significantly better at solving chemical proportional problems than field dependent students. Contrary to the findings of Fails (1985), Chandran, Treagrist, and Tobin (1987) showed that field-dependence/independence played no significant role in chemistry achievement. The study used the Hidden Figures Test (EFT, 1966) for measuring learning styles, researcher designed achievement post tests, and no pretest administration of tests were conducted. The researchers acknowledge the possible weak measures of both the students learning styles and chemistry achievement in their work as well as problems with the study design.

As academic standards continue to rise both within the state and across the nation more and more students from diverse cultural and socioeconomic backgrounds will populate our chemistry classrooms. With the belief that all children can learn science clearly stated, it is then necessary to meet the needs of all children who will be the chemistry students of tomorrow. The literature shows clearly there is a great deal of room for work in the realm of learning styles research which could aid in our understanding of student achievement in high school chemistry. Witkin, the father of cognitive styles,

reports that in the normal course of events, And Witkin has this to report on the stability of cognitive styles, "In the normal course of events, . . . we can predict with some accuracy that a person who has a particular style one day will have the same style the next day, month, and perhaps even years later" (p. 15). Kagan and Moss agreed with Witkin by saying that cognitive style is a term that refers to stable preference in mode of perceptual organization and conceptual categorization of the external environment (p. 74). If these researchers' tenets are correct then learning styles of students are fundamentally important in how children gather, code, analyze, and learn material.

Moreover, not only the learning styles of the students, but those of the teachers may play a key role as well. Acknowledging the importance of the chemistry teacher's style and approach is a necessity in understanding how children learn the science concepts. Joyce (1981) wrote on the differences between teaching styles and teacher approach. The educational environment in matching may be considered in terms of a teacher's preferred style which is often limited and unchanging, or as a teaching approach to be provided which may require the teacher to go beyond the teacher's preferred style. The teachers with a certain style might be matched with students with the same style or on the other hand the teachers' approach may be altered to meet, with versatility, the needs of the students.

Based on all of these findings, this study was designed to further the research of the effects of field dependence/independence on the achievement of secondary school chemistry students. With guidance offered by some of the researchers of the 1980's (Fails, 1985; Chandran, Treagrist, and Tobin, 1987) this study was tailored to better

examine the relationship by selecting a standardized valid, reliable measure of chemistry achievement and an accepted measure of learning styles produced by the Educational Testing Service. Furthermore, an extension to past research was made to include the importance of a possible teacher-student learning style match in the eventual student achievement results.

The study design and methodology will be discussed in detail in the next chapter.

Chapter 3

Design

This study examined the influence of matching teachers' and students' cognitive style on students' achievement in high school chemistry. The cognitive style of students and teachers were identified (field dependent or field independent) by use of the Embedded Figures Test. Students were administered the American Chemical Society's high school chemistry achievement test at the beginning and end of the second semester of a year course (pretest and post test). The two levels of student learning style in conjunction with the two levels of teacher learning style required the use of a 2x2 analysis of covariance statistical design for data analysis.

Setting

The study was conducted in a large urban, suburban public school system. The county's diverse 69,000 student population is educated by a staff of approximately 4,000 teachers who work in 76 elementary schools, 17 middle schools, and 12 senior high schools. Participants in the study were chemistry teachers and their 10th, 11th, and 12th grade general chemistry students enrolled in four comprehensive high schools.

Materials

The measures to be used to collect the data were the Embedded Figures Test (Karp and Konstadt, 1971) and the American Chemical Society's Standardized Chemistry Test

(1991). The Embedded Figures Test (EFT) is a standardized test which measures individual perceptual differences among people as well as individual ways of cognitive functioning in a variety of settings. It is a widely accepted measure of cognitive style which distinguishes between field dependent and field independent persons, describing their cognitive functioning as analytical or global. Performance on the EFT indicates the individual perceptual functioning in field dependence-independence. The reliability estimates for EFT range from .83 to .90 (Karp and Konstadt, 1971).

The American Chemical Society's Standardized Chemistry Test (ACS) is a standardized test to measure a high school student's knowledge of chemistry. It was used to measure the students' learning since it provided a good match with the county's chemistry curriculum. The match was determined by examining the nature of the test questions and comparing the questions to the objectives in the chemistry curriculum. For each chemistry unit, there were test questions which addressed the unit objectives. Questions addressed both content and process and measured analytical methods. A comparison of the nature of each question in the ACS test is found in appendix C. Each question was rated by a group of eight chemistry teachers as being analytical or non-analytical in intent. Appendix D shows whether the questions on the ACS test were covered during the first or second semester of the Anne Arundel County Public Schools' chemistry curriculum. Based on the scores of 5006 students in 64 high schools in the United States, the ACS test has a reliability of 0.90.

Procedures

Prior to the start of the project, a research committee from Anne Arundel County Public

Schools (AACPS) reviewed and approved the proposal. Once approval was granted, high school principals were approached and their cooperation was obtained. The next step was to meet with high school chemistry teachers. A letter was sent to chemistry teachers in the twelve high schools inviting them to an informational meeting. The project's objectives were explained and the benefits outlined. Any teacher concerns were addressed with an effort made to make the research non-threatening and non-intrusive. Twelve teachers attended the meeting and all twelve expressed a willingness to be part of the study. After instructions for taking the test were explained, the teachers were administered the Embedded Figures Test (EFT). On the basis of the test results, four teachers were selected for the study. These teachers represented extremes in test results for cognitive style, either field independent or field dependent. The Embedded Figures Test had a possible score of eighteen. The field independent teachers scored fifteen or greater and the field dependent teachers scored four or less. A table of Teacher Results is found in Appendix B. Participating teachers were then trained. Procedures and materials for administering the EFT and ACS examinations were reviewed in accordance with the test maker's instructions.

The participating students were students enrolled in the chemistry classes of the four selected teachers. A permission letter which explained the project's objectives and benefits was sent home with the potential student participants. The permission letters were returned the last week of first semester. A copy of the permission letter is found as Appendix J. Each class was administered the Embedded Figures Test and pretested with the American Chemical Society's High School Chemistry Test during the first week of the second semester. Once the teachers received the permission slips from the parents/guardians, a student count was generated and sent to the researcher. A total of

326 students participated in the research project. Test booklets and answer sheets for both the EFT and ACS were packaged and delivered to the teachers. The participating teachers administered the EFT and ACS in accordance with the test maker's instructions. A follow-up visit to the schools allowed for the collection of the completed EFT tests. The answers to the EFT were recorded in the student test booklet and were hand scored by the researcher. The answers to the ACS pretest were entered on a scanning sheet and were scored along with the results of the post test at the end of the semester.

After the EFT and ACS tests were administered, the teachers continued with their regular chemistry instructional program. There were no special contacts made between the researcher and the participants during the semester. Towards the last month of the semester, the researcher visited each project teacher to insure that booklets and answer sheets were available for administering the ACS post test.

The ACS post test was administered to students during the last week of the semester. The test booklets and the test sheets were collected by the researcher. Both the ACS pretest and post test sheets were electronically scored during the summer. A master list was compiled which matched the students to their EFT and ACS test results.

In compiling the master list, some of the students had incomplete data. The biggest problem was missing ACS post test data. Missing data occurred when students moved during the semester or were absent on the post test date. Although some students made arrangements to make up the post test, some students had conflicts and did not take the post test. Those students who did not have complete test results were not included in the final analysis. The final total of students in the analysis was 272.

Chapter 4

The study investigated the relationship between field dependence/field independence of students and teachers on student achievement in high school chemistry as measured by the American Chemistry Society's high school chemistry test. The basic design was a two by two design of pretest and post test results of field dependence/field independence of students matched to field dependence/field independence of teachers. Data analysis was conducted using the SPSS-X statistical package. Both descriptive and inferential statistical results were gathered and tabulated.

Means and standard deviations of the data collected representing pretest and post test scores on the ACS test are found in tables 1 and 2.

TABLE 1

AMERICAN CHEMICAL SOCIETY - PRETEST

VARIABLE	VALUE	LABEL	MEAN	STD DEV	CASES
FOR ENTIRE POPULATION			16.87	4.91	267
STUDENT	1	FIELD DEPENDENT	15.33	5.06	43
TEACHER	1	FIELD DEPENDENT	16.15	5.36	27
TEACHER	2	FIELD INDEPENDENT	13.94	4.30	16
STUDENT	2	FIELD INDEPENDENT	17.16	4.84	224
TEACHER	1	FIELD DEPENDENT	17.88	4.83	156
TEACHER	2	FIELD INDEPENDENT	15.51	4.46	68

TABLE 2

DESCRIPTION OF SUBPOPULATIONS - POST TEST

VARIABLE	VALUE	LABEL	MEAN	STD DEV	CASES
FOR ENTIRE POPULATION			18.30	6.22	267
STUDENT	1	FIELD DEPENDENT	16.21	5.06	43
TEACHER	1	FIELD DEPENDENT	17.00	5.72	27
TEACHER	2	FIELD INDEPENDENT	14.88	3.46	16
STUDENT	2	FIELD INDEPENDENT	18.70	6.35	224
TEACHER	1	FIELD DEPENDENT	19.64	6.65	156
TEACHER	2	FIELD INDEPENDENT	16.54	5.04	68

In the analysis of variance, the program looked at the pretest and post test scores of the students under the two conditions of teacher learning style. This data is presented in table 3.

TABLE 3

AMERICAN CHEMICAL SOCIETY - PRETEST

ANALYSIS OF VARIANCE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F	SIG.
BETWEEN GROUPS	121.49	1	121.49	5.12	.02
WITHIN GROUPS	6289.66	265	23.73		

The results of the analysis of variance indicated that field independent students scored significantly higher on the pretest than field dependent students and therefore were not equivalent groups. The results of the analysis of variance are reported in Table 3. To control for differences in the achievement of field dependent/independent students that existed at the beginning of the semester, an analysis of covariance was conducted on the post test scores using the pretest scores as a covariate. The results of the analysis of covariance are reported in Table 4.

TABLE 4

ANALYSIS OF COVARIANCE

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES	5993.20	1	5993.20	368.75	0.00
PRE	5993.20	1	5993.20	368.75	0.00
MAIN EFFECTS	46.60	2	23.30	1.43	0.24
STUDENT	17.61	1	17.61	1.08	0.30
TEACHER	27.92	1	27.92	1.72	0.19
2-WAY INTERACTIONS	5.59	1	5.59	0.34	0.56
STUDENT/TEACHER	5.59	1	5.59	0.34	0.56
EXPLAINED	6045.39	4	1511.35	92.99	0.00
RESIDUAL	4258.24	262	16.25		
TOTAL	10303.63	266	38.74		

The analysis of covariance indicated that there were no significant main effects or two-way interactions. This means that overall student scores on the ACS test did not significantly differ for field dependent or field independent students. In other words, the performance of the entire sample of field dependent or independent students did not differ in the American Chemical Society's test and did not differ whether they were taught by field dependent or independent teachers.

A subsequent statistical analysis of the data was conducted on the students reflecting an extreme degree of learning style in both field dependence and independence. This allowed for forty-three (43) field dependent students with a mean score of 5.1 out of a possible 18 on the Embedded Figures Test to be compared with 76 field independent students who scored a mean of 17.6 on the EFT. Clearly this analysis will view the results of students with strong tendencies toward the two ends of the learning styles scale. Tables 5 and 6 show the results of the select sample of students.

TABLE 5

AMERICAN CHEMICAL SOCIETY PRETEST

SELECTED POPULATION*

VARIABLE	VALUE	LABEL	MEAN	STD DEV	CASES
STUDENT	1	FIELD DEPENDENT	15.33	5.06	43
TEACHER	1	FIELD DEPENDENT	16.15	5.36	27
TEACHER	2	FIELD INDEPENDENT	13.94	4.30	16
STUDENT	2	FIELD INDEPENDENT	19.16	5.10	76
TEACHER	1	FIELD DEPENDENT	19.88	4.94	58
TEACHER	2	FIELD INDEPENDENT	16.83	5.06	18

*43 field dependent students (μ equals 5)
76 field independent students (μ equals 17.6)

TABLE 6

DESCRIPTION OF SUBPOPULATIONS - POST TEST

SELECTED POPULATION*

VARIABLE	VALUE	LABEL	MEAN	STD DEV	CASES
STUDENT	1	FIELD DEPENDENT	16.21	5.06	43
TEACHER	1	FIELD DEPENDENT	17.00	5.72	27
TEACHER	2	FIELD INDEPENDENT	14.88	3.46	16
STUDENT	2	FIELD INDEPENDENT	21.95	6.45	76
TEACHER	1	FIELD DEPENDENT	22.81	6.14	58
TEACHER	2	FIELD INDEPENDENT	19.17	6.81	18

In the analysis of variance, the program looked at the pretest and post test scores of the selected population of students under the two conditions of teacher learning style. This data is presented in table 7.

TABLE 7

AMERICAN CHEMICAL SOCIETY PRETEST

SELECTED POPULATION*

ANALYSIS OF VARIANCE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F	SIG.
BETWEEN GROUPS	581.03	2	290.51	13.20	.00
WITHIN GROUPS	5830.86	265	22.00		

The results of the analysis of variance shows a significant difference ($p < .05$) between field dependent and independent students as measured by the chemistry achievement pretest. Field independent students scored significantly higher than field dependent students. To control for differences in the achievement of field dependent and field independent students which existed at the beginning of the semester, an analysis of covariance was conducted on the post test scores using the pretest scores as the covariate. The results are contained in Table 8.

TABLE 8

AMERICAN CHEMICAL SOCIETY POST TEST

SELECTED POPULATION*

ANALYSIS OF VARIANCE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F	SIG.
BETWEEN GROUPS	1484.34	2	742.17	21.49	.00
WITHIN GROUPS	9152.77	265	34.54		

Again, field independent students scored significantly higher ($p < .05$) than field dependent students as measured by the American Chemical Society's post test.

In Table 9 the analysis of covariance with the selected population is shown. Since in the statistical analysis of the entire population, an analysis of covariance was conducted in order to account for the initial differences in the pretest scores of all students, the same procedures were followed in the statistical analysis of the selected student population. In Table 9, the results show significant differences between field independent/dependent students as measured by the American Chemical Society's test ($p=.01$). There were no significant differences for teacher effect.

TABLE 9

ANALYSIS OF COVARIANCE

SELECTED POPULATION*

SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F	SIGNIF OF F
COVARIATES	3152.14	1	3152.14	200.05	0.00
PRE	3152.14	1	3152.14	200.05	0.00
MAIN EFFECTS	150.23	2	75.12	4.77	0.01
STUDENT	122.19	1	122.19	7.76	.006
TEACHER	17.69	1	17.69	1.12	0.29
2-WAY INTERACTIONS	0.451	1	0.451	0.029	0.86
STUDENT/TEACHER	0.451	1	0.451	0.029	0.86
EXPLAINED	3302.82	4	825.71	52.40	0.00
RESIDUAL	1796.26	114	15.76		
TOTAL	5099.11	118	43.21		

Tables 10 and 11 show student gains and analysis of variance for students gains.

TABLE 10

STUDENT ACHIEVEMENT GAINS

SELECTED POPULATION*

VARIABLE	VALUE	LABEL	MEAN	STD DEV	CASES
STUDENT	1	FIELD DEPENDENT	0.88	3.83	43
TEACHER	1	FIELD DEPENDENT	1.04	4.35	27
TEACHER	2	FIELD INDEPENDENT	0.67	3.05	16
STUDENT	2	FIELD INDEPENDENT	2.79	4.06	76
TEACHER	1	FIELD DEPENDENT	2.93	4.12	58
TEACHER	2	FIELD INDEPENDENT	2.33	3.97	18
STUDENT	3	FIELD INTERMEDIATE	.78	4.15	148
TEACHER	1	FIELD DEPENDENT	1.06	4.24	84
TEACHER	2	FIELD INDEPENDENT	.40	4.03	64

TABLE 11

STUDENT ACHIEVEMENT GAINS

SELECTED POPULATION*

ANALYSIS OF VARIANCE

SOURCE	SUM OF SQUARES	D.F.	MEAN SQUARE	F	SIG.
BETWEEN GROUPS	215.42	2	107.71	6.48	.00
WITHIN GROUPS	4404.74	265	16.62		

Table 10 shows that field independent students have a greater gain then field dependent or field intermediate students. Across all student learning styles, students hsowed greater gains in field dependent teacher clasrooms. The analysis of variance data shown in Table 11 indicates significant gains of the field independent students.

Significant Findings

1. Field independent students have significantly higher achievement than the field dependent students as measured by the American Chemical Society's high school chemistry test.

2. Field independent students show significantly greater achievement gains than field dependent students as measured by the American Chemical Society's high school chemistry test.

3. Field independent students and field dependent students as a group tend to score higher with field dependent teachers both on the pretest and post test as measured by the American Chemical Society's high school chemistry test. However, the differences were not statistically significant.

Conclusions

The result of this study suggest that learning styles of students can significantly affect student chemistry achievement when the students considered have extreme learning style field dependent/independent characteristics. However, the matching of student learning style with equivalent teacher learning style was not shown to be significant. Students of both learning styles may achieve higher scores on the American Chemical Society's chemistry achievement test with field dependent teachers. This finding, however, was not statistically significant. Implications of these findings will be discussed in detail in the next chapter.

Chapter 5

Conclusion

The purpose of this research was to examine the relationship between field dependent/independent cognitive styles of students and teachers on student achievement as measured by the American Chemical Society's high school chemistry test. The null hypothesis stated:

> Differences in field dependent/independent cognitive styles of students and teachers should not affect students achievement in high school chemistry.

The results of the study indicate the null hypothesis should be rejected. The findings show clearly that students with strong field independent learning styles show significantly higher chemistry achievement and greater achievement gains. However, there is no statistically significant interaction effect between any one student-teacher learning style combination.

Discussion

Over the last three decades, extensive research has been conducted on cognitive style. A review of the research by Witkin, Moore, Goodenough and Cox (1977) discussed educational implications, but did not insightfully look into the relevance of cognitive style to academic achievement.

However, Goodenough and Karp (1961), Witkin (1974) and Coates (1975) found a common factor in cognitive style and tests of intelligence. Since academic skills overlap with intelligence, it was reasonable to consider a relationship between cognitive style and academic achievement. In the 1980's, Mitzel (1982) expressed the need to investigate several classes of variables and their relationship to chemistry achievement: (1) task variables (i.e., factors that affect a problem's difficulty, such as content), and (2) subject variables (i.e., student subject attributes that affect problem-solving achievement such as prior knowledge and cognitive style). Mitzel's paper stressed a need to analyze the evaluative instruments used for assessing student achievement.

Furthermore, Fails (1985) and Chandran et al. (1987) delves into specifically analyzing field dependence/independence and its effect on problem solving and achievement in high school chemistry.

Based on this work and comments from the authors Fails (1985) and Chandran et al. (1987), this study was designed to measure the effects of student and teacher field dependent/independent cognitive styles on chemistry student achievement using a well respected measure of learning style and a standardized reliable chemistry achievement instrument.

Fails (1985) used the Find-A-Shape Puzzle (FASP) and found that field independent students were significantly better at solving chemical proportion problems than field dependent students. Chandran, Treagrist, and Tobin (1987) showed that field

dependence/independence played no significant role in chemistry achievement. The study used the Hidden Figures Test (EFT, 1966) for measuring learning styles, researcher designed achievement post tests and no pretest were conducted. The problems cited in the work of the above authors lead this researcher to design a study which addressed the mentioned weaknesses.

The analysis of the data indicated that cognitive styles of students do affect their achievement and cognitive styles of teachers may affect it. In fact, when the analysis of strongly field dependent and strongly field independent students was examined, the data showed greater achievement gains for the students when they were coupled with a field dependent teacher. Although these findings are not statistically significant, they do warrant further study and could have great impact on the success of a diverse population of children who will be electing to take chemistry in the future.

There are several systemic national programs which have a main goal of systemic reform of science instruction. Programs like Project 2061 from the American Association for the Advancement of Science and Science, Scope and Sequence from the National Science Teachers Association have called for science instruction which is available for all Americans. Based upon the results of this study, question to be addressed is the degree to which all Americans can achieve success in science instruction.

It appears that those learners which are field independent show significantly greater achievement in chemistry. If "science for all Americans" is to become a reality, several

questions need to be answered. The first question is to define the role of achievement for success to be met. Is it sufficient just to have students enrolled in a science course? If achievement is important, what additional support must be provided for field dependent students? Since both field dependent and field independent students showed greater achievement gains when coupled with a field dependent teacher, a second question would focus on the selection of teachers based on their learning style. A teacher's learning style could become a central theme of inservice and perservice in teacher preparation programs.

Since the field independent students showed significantly greater achievement, a logical question is whether they were "smarter." Any number of techniques could be used to establish "smarter" criteria, for example I.Q. scores or grade point average. Future research could address the "smarter" aspects on learning style and achievement. The literature discusses cognitive flexibility, the ability to modify learning style to meet the learning environment. Perhaps field independent learners have greater cognitive flexibility than field dependent learners. The interaction of various variables like intelligence, and cognitive flexibility in affecting achievement is another study in itself.

As the data tables indicate, only 43 students of the 272 tested were field dependent. Do students reaching high school chemistry preselect themselves? Have the been counseled by teachers or peers to enroll in certain courses? With additional math credits now required for graduation, the majority of students have the math requirement prerequisite to enroll in chemistry. A questionnaire could be helpful in determining why so few field

dependent students take chemistry.

In the last five years, the national movement for performance assessment testing has intensified. Authentic, performance assessment questions appear in most nationally distributed science textbooks and many states have or are initiating a mandated performance assessment program. The data in this study seems to indicate that the national movement towards group efforts in solving problems may be off-base. In states like Maryland and California, students work in groups to solve problems, thus favoring the field dependent learning style. However, the data shows that greater achievement is associated with field independent learners who prefer to work alone. Obviously there are social and political forces at work deciding how resources will be used and which group of Americans will be addressed and to what degree.

With this new knowledge it may be pertinent to consider an idea such as Joyce (1981) suggested when he said that although a teacher's preferred style is often limited and unchanging, their teaching approach may, with work, be altered to meet the diverse needs of the students. We have descriptors and an operationalized understanding of what it means to show characteristics of field dependence and field independence. Through inservices and workshops, teachers could be offered a heightened awareness of this learning style concept and instructional approaches which focus on the characteristics of both styles. All too often it is assumed that teachers are opposed to change, but all to infrequently are rationales, incentives, and inservice training provided for them to attempt to do so. During this time where an awareness of the needs of all children is a

national school focus, workshops designed with the theme of understanding the importance of learning styles in the content areas could yield valuable results. Barbe and Milone (1980) claimed that children with mixed modality strengths seem to have an advantage in the classroom. Though they are no more or less intelligent than students with a single strength, they are able to process information more effectively. Through workshops and inservices, teachers would increase their scope of instructional techniques while becoming more aware of the needs of children who will be populating their classrooms.

It is necessary to note that the findings of this study cannot be generalized beyond its limited scope because of the sample size and limited achievement measures. However, the study does yield much fruit for future research.

Future Research

As the study produced significant findings linking learning styles of students and teachers to high school student chemistry achievement, many more paths for future research in this area are uncovered. Initially, there is the need for a similar study to be conducted with a large culturally diverse randomized student and teacher sample population, several reliable measures of chemistry achievement, and data collection over a longer period of time. This type of design is warranted and would offer the generalizability of its results.

Secondly, it would be interesting to conduct a case study on a single teacher's chemistry classroom over an academic year. Details of the environment and the teacher-student

interactions would add to the richness of the study on the effects of field dependence/independence on achievement.

Data was collected only from one science course, chemistry. The obvious need for data from other science courses and other grades is apparent. Research needs to determine if physics, earth science courses, and biology courses would produce similar results. The majority of students in chemistry reflect an age group different from introductory science courses and courses elected in the eleventh or twelfth grades. A long term study might follow a group of students enrolled in science from eighth through twelfth grade. It would be interesting to see if science courses or teachers tend to preselect particular students. If there are achievement differences in high school chemistry, what of achievement in advanced placement science courses? To be more integrated, parallel studies could examine achievement in math courses. Since there is agreement that math and science ability is related, math achievement results might be related to learning styles.

Lastly, the issue of confounding variables must be addressed. As was noted in the literature review the definition of learning styles is not a single one upon which all researchers agree. With such a nebulous understanding of the concept, the number of variables increased with the researchers use to describe it. Hence, a proposed study designed to describe and define details in the relationship of field dependence/dependence to chemistry achievement would profit the entire learning styles community. Such studies could be designed to include capturing student interest and motivation, teacher

preparation, classroom environment, instructional foci, and home support.

Ekstrom (1976) reported that few elementary teachers of grades two and five showed a consistent relationship between their learning styles and teaching behavior in reading or mathematics. However, Neil (1990) found that an understanding of cognitive style can aid teachers in broadening teaching methods and curricula to accommodate more students preferred cognitive styles. In a 1981 study, Mahlios found that approaches used in classroom teaching relate to a teacher's style. Field dependent teachers interacted significantly more often with students in small groups and individually while field independent initiated a significantly greater number of interactions with pupils as a whole class. In addition, Mahlios (1981) found field dependent teachers asked more factual questions, whereas field independent teachers asked more analytical level questions. Field independent teachers asked more academic questions , but field dependent teachers encouraged students to apply principles. Field independent teachers yielded more feedback to students who gave both correct and incorrect answers. Apparently, field dependent and field independent teachers vary in their academic interactions, in the context of their interactions with pupils, in the conceptual level of instructional activity, and in the type of feedback they give students. Saracho (1988) suggests that both field dependent/independent students learn better when the concepts and content are consistent with their cognitive style. With the achievement gains indicated in Tables 10 and 11 of this dissertation and the literature support cited, further research is warranted to give greater understanding of the link of learning styles of students and teachers to student achievement in high school chemistry.

Anne Arundel County Public Schools
Building Futures . . .
Carol S. Parham, Ed.D., *Acting Superintendent of Schools*

2644 Riva Road
Annapolis, Maryland 21401
Telephone: (410) 222-5000

December 15, 1992

Dear High School Chemistry Teacher,

I hope that you are ready for the holidays and know you will enjoy the time with your family and friends. We can all use the time to energize our batteries for second semester.

At the chemistry inservice in October, I mentioned that I am involved in a research project second semester to investigate the relationship between learning style and achievement in chemistry. The project consists of two tests, the Hidden Figures Test and the American Chemical Society's (ACS) High School Achievement Test in Chemistry. The Hidden Figures Test takes about 15 minutes to administer to students and the ACS test about 30 minutes. All tests would be scored by the Science Office. A training session to learn how to administer the tests will be held on Thursday, January 7, 1993, from 3:00 to 4:30 p.m. at Old Mill Senior High School. The meeting will be held in the Science Department. You will be paid $24 for the training and refreshments will be served.

Please call my office at 222-5451 and confirm your attendance at the training session.

Sincerely,

Thomas Custer
Coordinator of Science

TC/mb

Appendix B

Teacher Results - Embedded Figures Test

Teacher	Score	Cognitive Style
A	17	Field independent
B	16	Field Independent
C	4	Field dependent
D	2	Field dependent

APPENDIX C: TEACHER A – STUDENT RESULTS

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
A-1	6/9	7/9	13/18		X	14	15
A-2	7/9	9/9	16/18		X	21	20
A-3	1/9	5/9	6/18	X		12	16
A-4	1/9	2/9	3/18	X		15	15
A-5	6/9	6/9	12/18		X	11	17
A-6	7/9	9/9	16/18		X	15	11
A-7	4/9	8/9	12/18		X	14	14
A-8	8/9	8/9	16/18		X	17	15
A-9	0/9	2/9	2/18	X		10	14
A-10	2/9	5/9	7/18	X		12	14
A-11	3/9	7/9	10/18		X	14	15
A-12	6/9	5/9	11/18		X	16	21
A-13	6/9	7/9	13/18		X	12	15
A-14	8/9	6/9	14/18		X	12	10
A-15	7/9	8/9	15/18		X	8	9
A-16	6/9	6/9	12/18		X	15	14
A-17	3/9	8/9	11/18		X	19	21
A-18	1/9	3/9	4/18	X		16	19
A-19	8/9	8/9	16/18		X	9	9
A-20	5/9	8/9	13/18		X	12	14
A-21	6/9	7/9	13/18		X	17	20
A-22	6/9	6/9	12/18		X	15	12
A-23	7/9	7/9	14/18		X	16	22
A-24	6/9	6/9	12/18		X	11	10
A-25	6/9	9/9	15/18		X	18	19
A-26	2/9	2/9	4/18	X		11	9
A-27	4/9	7/9	11/18		X	26	16
A-28	9/9	8/9	17/18		X	18	11
A-29	3/9	5/9	8/18	X		8	12
A-30	3/9	7/9	10/18		X	12	11
A-31	9/9	9/9	18/18		X	17	22
A-32	0/9	3/9	3/18	X		15	10
A-33	9/9	9/9	18/18		X	11	13

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
A-34	8/9	9/9	17/18		X	21	15
A-35	9/9	7/9	16/18		X	18	15
A-36	4/9	4/9	8/18	X		6	12
A-37	2/9	8/9	10/18		X	17	14
A-38	6/9	9/9	15/18		X	13	8
A-39	4/9	5/9	9/18		X	17	14

APPENDIX D: TEACHER B -- STUDENT RESULTS

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
B-1	5/9	9/9	14/18		X	13	17
B-2	8/9	9/9	17/18		X	20	26
B-3	2/9	5/9	7/18	X		22	18
B-4	5/9	8/9	13/18		X	12	13
B-5	0/9	3/9	3/18	X		14	16
B-6	0/9	0/9	0/18	X		12	11
B-7	8/9	9/9	14/18		X	19	20
B-8	4/9	7/9	11/18		X	19	18
B-9	6/9	9/9	15/18		X		
B-10	6/9	4/9	10/18		X	14	15
B-11	5/9	9/9	14/18		X	14	17
B-12	0/9	0/9	0/18	X		14	15
B-13	9/9	9/9	18/18		X	18	15
B-14	5/9	7/9	12/18		X	18	20
B-15	9/9	9/9	18/18		X	24	26
B-16	6/9	9/9	15/18		X	7	7
V-17	8/9	8/9	16/18		X	11	10
B-18	8/9	8/9	16/18		X	14	17
B-19	7/9	8/9	15/18		X	9	13
B-20	4/9	9/9	13/18		X	16	0
B-21	7/9	8/9	16/18		X	21	29
B-22	8/9	9/9	17/18		X	15	14
B-23	3/9	3/9	6/18	X		17	19
B-24	7/9	8/9	15/18		X		
B-25	7/9	7/9	14/18		X	8	8
B-26	5/9	6/9	11/18		X	19	24
B-27	6/9	7/9	13/18		X	27	28
B-28	4/9	6/9	10/18		X	15	20
B-29	6/9	7/9	13/18		X	19	21
B-30	7/9	9/9	16/18		X	19	19
B-31	9/9	8/9	17/18		X	10	13
B-32	9/9	9/9	18/18		X	21	25
B-33	7/9	9/9	16/18		X	16	16

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
B-34	4/9	7/9	11/18		X	14	15
B-35	7/9	9/9	16/18		X	16	18
B-36	5/9	9/9	14/18		X	12	13
B-37	9/9	9/9	18/18		X	24	28
B-38	3/9	4/9	7/18	X		19	17
B-39	6/9	9/9	15/18		X	23	22
B-40	0/9	3/9	3/18	X		20	21
B-41	7/9	9/9	16/18		X	13	16
B-42	9/9	9/9	18/18		X	11	20
B-43	7/9	6/9	13/18		X	10	15
B-44	5/9	8/9	13/18		X	11	19
B-45	8/9	8/9	16/18		X	20	18
B-46	5/9	8/9	13/18		X	12	18
B-47	7/9	8/9	15/18		X	20	17
B-48	8/9	9/9	17/18		X	20	21
B-49	3/9	5/9	8/18	X		13	13
B-50	3/9	7/9	10/18		X	12	10
B-51	6/9	7/9	13/18		X	21	20
B-52	9/9	7/9	16/18		X	13	10
B-53	9/9	8/9	17/18		X	24	32
B-54	3/9	9/9	12/18		X	17	13
B-55	5/9	9/9	14/18		X	20	20
B-56	9/9	9/9	18/18		X	21	24
B-57	0/9	0/9	0/18	X		12	9
B-58	8/9	9/9	17/18		X	16	21
B-59	9/9	9/9	18/18		X	10	12
B-60	7/9	9/9	16/18		X	16	24
B-61	9/9	9/9	18/18		X	12	9
B-62	5/9	8/9	13/18		X	20	20

APPENDIX E: TEACHER C – STUDENT RESULTS

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
C-1	8/9	9/9	17/18		X	21	21
C-2	8/9	9/9	17/18		X	18	14
C-3	8/9	9/9	17/18		X	11	12
C-4	6/9	7/9	13/18		X	25	17
C-5	9/9	9/9	18/18		X	21	27
C-6	2/9	4/9	6/18	X		12	12
C-7	9/9	9/9	18/18		X	7	12
C-8	3/9	2/9	5/18	X		17	12
C-9	9/9	9/9	18/18		X	20	22
C-10	1/9	3/9	4/18	X		23	28
C-11	6/9	7/9	13/18		X	19	24
C-12	6/9	8/9	14/18		X	23	30
C-13	3/9	6/9	9/18		X	17	11
C-14	6/9	9/9	15/18		X	21	18
C-15	1/9	4/9	5/18	X		24	19
C-16	2/9	5/9	7/18	X		25	29
C-17	4/9	6/9	10/18		X	17	17
C-16	9/9	8/9	17/18		X	23	31
C-19	5/9	5/9	10/18		X	15	18
C-20	9/9	6/9	15/18		X	20	22
C-21	5/9	8/9	13/18		X	19	30
C-22	4/9	6/9	10/18		X	16	18
C-23	9/9	9/9	18/18		X	25	31
C-24	9/9	8/9	17/18		X	22	27
C-25	7/9	5/9	12/18		X	22	29
C-26	9/9	9/9	18/18		X	18	24
C-27	9/9	9/9	18/18		X	21	24
C-28	3/9	8/9	11/18		X	21	27
C-29	9/9	8/9	17/18		X	21	26
C-30	7/9	9/9	16/18		X	24	29
C-31	8/9	9/9	17/18		X	19	20
C-32	7/9	9/9	16/18		X	25	36
C-33	9/9	9/9	18/18		X	16	18

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
C-34	3/9	5/9	8/18	X		6	12
C-35	1/9	3/9	4/18	X		14	8
C-36	9/9	9/9	18/18		X	13	15
C-37	4/9	8/9	12/18		X	19	22
C-38	8/9	7/9	15/18		X	22	22
C-39	7/9	9/9	16/18		X	19	25
C-40	9/9	9/9	18/18		X	18	26
C-41	5/9	5/9	10/18		X	15	16
C-42	8/9	9/9	17/18		X	20	13
C-43	8/9	9/9	17/18		X	25	30
C-44	8/9	9/9	17/18		X	22	26
C-45	9/9	9/9	18/18		X	15	14
C-46	6/9	6/9	12/18		X	22	19
C-47	9/9	9/9	18/18		X	29	27
C-48	1/9	6/9	7/18	X	X	7	16
C-49	4/9	4/9	8/18	X		11	20
C-50	2/9	4/9	6/18	X		19	21
C-51	7/9	8/9	15/18		X	17	14
C-52	8/9	9/9	17/18		X	20	29
C-53	8/9	9/9	17/18		X	25	33
C-54	2/9	7/9	9/18		X	16	28
C-55	4/9	6/9	10/18		X	18	19
C-56	9/9	9/9	18/18		X	32	31
C-57	4/9	4/9	8/18	X		20	20
C-58	7/9	7/9	14/18		X	20	22
C-59	5/9	6/9	11/18		X	12	18
C-60	6/9	8/9	14/18		X	13	9
C-61	7/9	7/9	14/18		X	17	20
C-62	1/9	5/9	6/18	X		19	21
C-63	2/9	3/9	5/18	X		17	16
C-64	5/9	3/9	8/18	X		21	21
C-65	8/9	8/9	17/18		X	22	23
C-66	3/9	6/9	9/18		X	18	15

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
C-67	9/9	8/9	17/18		X	20	28
C-68	8/9	7/9	15/18		X	16	21

APPENDIX F: TEACHER D -- STUDENT RESULTS

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
D-1	8/9	9/9	17/18		X	17	14
D-2	6/9	7/9	13/18		X	12	12
D-3	8/9	9/9	17/18		X	16	15
D-4	2/9	3/9	5/18	X		15	16
D-5	4/9	6/9	10/18		X	16	14
D-6	5/9	7/9	16/18		X	13	12
D-7	7/9	9/9	16/18		X	7	15
D-8	6/9	6/9	12/18		X	18	15
D-9	3/9	7/9	10/18		X	15	17
D-10	0/9	4/9	4/18	X		9	12
D-11	6/9	8/9	14/18		X	16	21
D-12	2/9	5/9	7/18	X		13	10
D-13	6/9	4/9	10/18		X	16	14
D-14	4/9	7/9	11/18		X	11	6
D-15	4/9	7/9	11/18		X	11	13
D-16	7/9	8/9	15/18		X	14	14
D-17	4/9	6/9	10/18		X	12	13
D-18	2/9	7/9	9/18		X	15	19
D-19	3/9	3/9	6/18	X		10	15
D-20	5/9	6/9	11/18		X	15	15
D-21	8/9	9/9	17/18		X	11	19
D-22	8/9	9/9	17/18		X	20	25
D-23	7/9	8/9	15/18		X	19	16
D-24	4/9	7/9	11/18		X	22	21
D-25	9/9	9/9	18/18		X	26	28
D-26	4/9	7/9	11/18		X	20	19
D-27	9/9	9/9	18/18		X	17	18
D-28	1/9	2/9	3/18	X		22	24
D-29	8/9	9/9	17/18		X	17	16
D-30	7/9	9/9	16/18		X	13	13
D-31	9/9	9/9	18/18		X	16	17
D-32	4/9	7/9	11/18		X	12	11
D-33	4/9	7/9	11/18		X	10	13

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
D-34	5/9	7/9	12/18		X	15	15
D-35	7/9	9/9	16/18		X	13	12
D-36	9/9	9/9	18/18		X	29	37
D-37	5/9	8/9	13/18		X	9	16
D-38	2/9	5/9	7/18	X		23	22
D-39	2/9	2/9	4/18	X		14	7
D-40	2/9	4/9	6/18	X		20	20
D-41	9/9	9/9	18/18		X	27	21
D-42	6/9	8/9	14/18		X	18	8
D-43	8/9	9/9	17/18		X	21	28
D-44	9/9	8/9	17/18		X	21	20
D-45	7/9	8/9	17/18		X	19	16
D-46	5/9	6/9	11/18		X	20	20
D-47	7/9	6/9	13/18		X	13	13
D-48	4/9	7/9	11/18		X	16	20
D-49	6/9	6/9	12/18		X	16	13
D-50	6/9	9/9	15/18		X	12	14
D-51	3/9	6/9	9/18		X	14	15
D-52	9/9	9/9	18/18		X	19	24
D-53	3/9	6/9	9/18		X	15	10
D-54	9/9	9/9	18/18		X	17	27
D-55	3/9	7/9	10/18		X	21	26
D-56	9/9	9/9	18/18		X	16	16
D-57	5/9	8/9	13/18		X	14	6
D-58	9/9	9/9	18/18		X	25	29
D-59	6/9	5/9	11/18		X	13	13
D-60	5/9	8/9	13/18		X	13	14
D-61	9/9	9/9	18/18		X	23	21
D-62	9/9	9/9	18/18		X	19	21
D-63	8/9	8/9	16/18		X	17	20
D-64	9/9	9/9	18/18		X	19	27
D-65	9/9	9/9	18/18		X	17	17
D-66	6/9	9/9	15/18		X		

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
D-67	8/9	9/9	17/18		X	19	23
D-68	5/9	9/9	14/18		X	13	15
D-69	6/9	7/9	13/18		X	10	12
D-70	9/9	9/9	18/18		X	17	19
D-71	9/9	8/9	17/18		X	17	27
D-72	3/9	2/9	5/18	X		17	21
D-73	1/9	3/9	4/18	X		21	18
D-74	4/9	5/9	9/18		X	14	20
D-75	5/9	8/9	13/18		X	11	8
D-76	7/9	9/9	16/18		X	28	28
D-77	6/9	5/9	11/18		X	10	9
D-78	8/9	9/9	17/18		X	16	18
D-79	9/9	9/9	18/18		X	15	15
D-80	0/9	4/9	4/18	X		12	17
D-81	9/9	9/9	18/18		X	17	26
D-82	7/9	7/9	14/18		X	23	31
D-83	4/9	7/9	11/18		X	17	23
D-84	8/9	9/9	17/18		X	27	27
D-85	8/9	9/9	17/18		X	10	19
D-86	8/9	9/9	17/18		X	17	17
D-87	5/9	6/9	11/18		X	18	19
D-88	7/9	9/9	16/18		X	15	17
D-89	7/9	8/9	15/18		X	24	23
D-90	7/9	8/9	15/18		X	20	19
D-91	5/9	7/9	12/18		X	18	17
D-92	7/9	9/9	16/18		X	19	15
D-93	3/9	6/9	9/18		X	15	13
D-94	8/9	9/9	17/18		X	25	27
D-95	3/9	8/9	11/18		X	19	15
D-96	5/9	5/9	10/18		X	8	13
D-97	9/9	8/9	17/18		X	29	35
D-98	8/9	9/9	17/18		X	24	26
D-99	4/9	9/9	13/18		X	23	20

STUDENT NUMBER	SECTION 2 RIGHT	SECTION 3 RIGHT	TOTAL	FIELD DEPENDENT	FIELD INDEPENDENT	PRE TEST	POST TEST
D-100	7/9	9/9	16/18		X	27	32
D-101	3/9	7/9	10/18		X	12	15

APPENDIX G

American Chemical Society's High School Test

Field Dependent
- o
- o
- o

Field Independent
search for factual clues
analytical
non-analytical

Question Number	Classification A=analytical N=non-analytical	Criteria	Number of EightTeachers Which Agreed
41	A	Problem solving	8
42	N	Factual	8
43	A	Problem solving	8
44	A	Balance equation, math	7
45	N	Recall definition	6
46	N	Sight identification	7
47	N	Multiple choice recall	8
48	A	Problem solving	8
49	N	Recall	6
50	N	Recall	7
51	A	Data review, problem solving	8
52	A	Problem solving	8
53	A	Problem solving	8
54	N	Recall	8
55	A	Problem solving	8
56	A	Data analysis, problem solving	6
57	N	Recall	6
58	N	Recall	7
59	A	Balance Equation, problem solving	8
60	A	Problem solving	7
61	A	Interpret data, extend	5
62	N	Recall	6
63	N	Recall	8
64	N	Recall	8
65	N	Recall	6
66	A	Interpretation	7
67	N	Recall	8
68	N	Recall	8
69	N	Recall	6
70	N	Recall	8
71	A	Problem solving	8
72	A	Problem solving	6
73	N	Recall	7
74	N	Recall	8
75	A	Problem solving	8
76	A	Interpretation, problem solving	6
77	N	Recall	5
78	A	Problem solving	6
79	A	Problem solving	7
80	N	Recall	

APPENDIX H

Semester Coverage of American Chemical Society's Test Questions

First Semester Questions	Second Semester Questions
41	48
42	50
43	51
44	52
45	55
46	56
47	57
49	58
53	59
54	61
60	62
65	63
66	64
	67
	68
	69
	70
	71
	72
	73
	74
	75
	76
	77
	78
	79
	80
Thirteen out of 50 questions	Twenty-seven out of 50 questions

APPENDIX I

RESEARCH USING HUMAN SUBJECTS APPLICATION

I. The purpose of the research is to examine the relationship between field dependence/field independence of students and teachers on student achievement in high school chemistry as measured by the American Chemical Society's High School Chemistry Test.

II. Subject selection

a. Subject will be high school chemistry students in Anne Arundel County Public Schools. Students will be selected according to the field dependence/independence on their teacher.

b. They will not be selected due to any special religious or economic conditions.

III. The study will be centered in Anne Arundel County using students in the public high schools. Participants will be chemistry students and chemistry teachers. During the fall semester of 1992, chemistry teachers will be administered the Embedded Figures Test (Educational Testing Services). Four teachers will be selected for the project: two teachers who exhibit extreme field dependence and two teachers who exhibit extreme field independence. Students of these four teachers will become the student population. To examine the variability in cognitive style, data will be compared for each cognitive style for students in the classes. Since the classes will be selected according to the teachers' cognitive style, the number of field dependent and field independent students will vary with each class.

Before the project can be implemented, a research committee will need to review and approve the committee. Once approval is granted, school administrators will need to be approached for cooperation. The investigator plans to meet with each principal and school administrators to explain the project and bring them on board as part of the project. As a cooperative, each principal will be supportive of the project. Once the principals have been apprised, the next step is to meet with the chemistry teachers. The project's objectives will be explained and the benefits outlined. Any concerns will be addressed with an effort to make the research non-threatening and nonintrusive.

A timeline will be developed in order to allow testing to begin the first week of the spring semester of the 1992-93 school year.

The measures to be used to collect the data will be the Embedded Figures Test (Karp and Konstadt, 1971) and the American Chemical Society's Standardized Chemistry Test. The Embedded Figures Test (EFT) is a standardized test which measures individual perceptual differences among people as well as individual ways of cognitive functioning in a variety of settings. It is a widely accepted measure of cognitive style which distinguishes between field-dependent and field-independent persons, describing their cognitive functioning as analytical or global. Performance on the EFT indicates the individual perceptual functioning in field-dependence-independence. The reliability estimates for EFT range from .83 to .90 (Karp and Konstadt, 1971). The American Chemical Society's Standardized Chemistry Test is a standardized test to measure a student's knowledge of chemistry. It will be used to measure the student's learning.

Before administering the EFT to students, a permission letter will go home to parents. Parents who object will not have their children be part of the study. Once students have parental approval, they will be administered the EFT. The cognitive style results will be shared with the students at the conclusion of the research project. Each of the chemistry teachers will also have his/her cognitive style identified using the EFT.

In order to measure the growth of chemistry knowledge, the students will be pre- and post tested using the American Chemical Society's Chemistry Test.

IV. No risks have been identified.

V. Students will be identified according to student ID numbers and results will be released to individual students upon request. Any published results will mask the identity of students.

VI. Students and teachers will be given the research background for field dependence/independence cognitive learning style. The research suggests a connection between cognitive style and achievement and this knowledge might be beneficial to students and teachers. No deception is involved in the project. A sample permission letter is attached.

APPENDIX J

PARENTAL CONSENT FORM

Identification of Research Project Purpose

The purpose of the research is to examine the relationship between field dependence/field independence of students and teachers on student achievement in high school chemistry as measured by the American Chemical Society's High School Chemistry Test.

Background

There are a number of tests which have been used to identify cognitive styles of students. Tests like the Meyers-Briggs Personality Test and the Embedded Figures Test can help students to identify how they learn information. In this research project, the connection between cognitive style and achievement in chemistry is being investigated. It is acticipated that students will benefit from knowing their cognitive styles and that this knowledge might increase achievement in school.

If you would like your child to participate in the project, please have this form returned to your child's chemistry teacher. The project will start the second semester. All information collected in the project is confidential and no student names will be identified at any time. Upon request of the chemistry teacher, your child's cognitive style will be given.

I give permission for _____ to participate in the cognitive style project being conducted by the Science Office of Anne Arundel County Public Schools.

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