



Achievement as a function of learning style preference in beginning computer programming courses
by Roderick Morris Thronson

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University

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Abstract:

The general area of concern of this study was: Is there a relationship between learning style and achievement in beginning computer programming classes? In order to look at this concern in greater depth, data were collected and analyzed as part of this study: 1. to determine if achievement in beginning computer programming classes is a function of learning style as well as other selected factors; 2. to determine if student learning style changes or is modified after experiencing beginning programming instruction and, if such changes exist, whether they are related to achievement.

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The data were collected using two instruments. One was a learning style measure, the Gregorc Style Delineator.

The other instrument was a questionnaire in which the participants were asked questions regarding various achievement history, selected course history and other demographic factors.

Specifically, the results of this study led the investigator to conclude the following: 1. Achievement in beginning computer programming classes was not a function of learning style.

The factors of good high school performance, high college grade point average, junior, senior, or graduate status, high self-perception of one's computer programming ability, more years of high school mathematics experienced and being a female were predictors that accounted for the most letter grade variance in the prediction equation derived from the multiple regression analysis.

2. Last week learning style was significantly dependent on first week learning style. Where a change in learning style occurred, the change seemed to be towards the random and abstract ends of Gregorc's continue. There was no systematic or significant relationship to course content or achievement.

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ACHIEVEMENT AS A FUNCTION OF LEARNING STYLE
PREFERENCE IN BEGINNING COMPUTER
PROGRAMMING COURSES

by

Roderick Morris Thronson

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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APPROVAL

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Roderick Morris Thronson

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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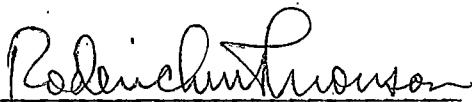
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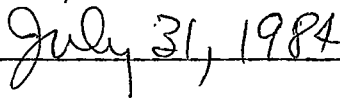
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ABSTRACT

The general area of concern of this study was: Is there a relationship between learning style and achievement in beginning computer programming classes?

In order to look at this concern in greater depth, data were collected and analyzed as part of this study:

1. to determine if achievement in beginning computer programming classes is a function of learning style as well as other selected factors;
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The data were collected using two instruments. One was a learning style measure, the Gregorc Style Delineator. The other instrument was a questionnaire in which the participants were asked questions regarding various achievement history, selected course history and other demographic factors.

Specifically, the results of this study led the investigator to conclude the following:

1. Achievement in beginning computer programming classes was not a function of learning style.

The factors of good high school performance, high college grade point average, junior, senior, or graduate status, high self-perception of one's computer programming ability, more years of high school mathematics experienced and being a female were predictors that accounted for the most letter grade variance in the prediction equation derived from the multiple regression analysis.

2. Last week learning style was significantly dependent on first week learning style. Where a change in learning style occurred, the change seemed to be towards the random and abstract ends of Gregorc's continua. There was no systematic or significant relationship to course content or achievement.

CHAPTER 1

INTRODUCTION

Learning style is a complex subject because of the varied dimensions that are associated with the concept. Definitions of learning style are numerous and depend upon the theory and/or instrument involved; however, Cornett (1983:9) has provided a general, summative definition that appears to be in accord with most, if not all, of the researchers when she stated that "...Styles then are overall patterns that give general direction to learning behavior."

One of the best ways to view learning style is through the approach described by Keefe (1979) and Cornett (1983) as the three learning style dimensions -- cognitive, affective and physiological. Within each of these dimensions can be found numerous studies and theories.

The investigator chose to concentrate his efforts on the cognitive dimension which is defined by Cornett (1983:9) as "the ways we decode, encode, process, store and retrieve information." The theories included within this dimension tend to fall into continua or dualities of opposite characteristics. People tend to function along these continua in varying degrees. An extensive examination of the literature revealed that most of the theories involve

these continua or combinations of several of them when referring to learning style.

Three theories within the cognitive area of learning style are presented by the respective researchers using a quaternary approach. This quaternary approach tends to separate these theories from all of the other theories within the cognitive area. These three theories are Kolb's Experiential Model, McCarthy's 4MAT Model and Gregorc's Phenomenological Model. For the purposes of this introduction, only the pioneering work of Gregorc will be discussed in detail as Gregorc's Style Delineator was the learning style instrument utilized to collect data in this investigation.

Gregorc's work was based on what he called the "information acquisition phase" of learning. In the phenomenological approach of Gregorc, the vertical axis is represented by the thinking processes of concrete versus abstract and the horizontal axis represents the ordering duality of random versus sequential. (Gregorc, 1979)

Gregorc explains his phenomenological viewpoint as follows:

"[it] consists of distinctive and observable behaviors... that 'tell' us how [our] minds relate to the world... reflecting specific mind qualities... [that] serve as mediators as we learn and act on our environment... they are manifested as behavior and register in our conscious minds as preferred means of learning and teaching. (Gregorc, 1979:19)"

The four quadrants he has developed represent the learning

styles of concrete sequential, abstract sequential, abstract random, and concrete random. Figure 1 illustrates Gregorc's Phenomenological Model.

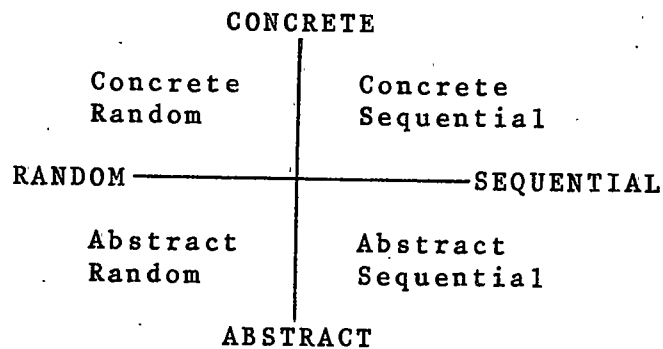


Figure 1. The Four Learning Styles of the Gregorc Phenomenological Model

Another topic of interest to this investigation was achievement. Relative to achievement, Dunn and Dunn (1979) report numerous studies linking teaching towards specific learning styles to increased achievement. However, one recent doctoral dissertation (Mehdikhani, 1983) was discovered reporting that there was no significant relationship between learning style and achievement as measured by end-of-course grades. Specifically, the Mehdikhani (1983) study looked at teacher teaching style, teacher learning style and student learning style and found no relationship between student achievement and a match between student and teacher learning style. Further, Hunter (1980:83) indicated that "...while learning styles assessments provide an excellent diagnostic tool for

counseling and individualizing instruction, the identification of the achiever has not been significantly clarified." This presents a dilemma to which the investigator hoped to add information.

In addition, the prominent research team of Dunn and Price (1980) cited a need for further studies along the lines of learning style and achievement. Referring specifically to computer science, Konvalina, Stephens and Wileman (1983) cited a need for further research into factors influencing achievement in computer science. Dunn and Price (1980:35) stated that "...additional investigations need to be conducted to determine the relationship(s) between learning style and achievement." In speaking of computer science and the need for research relative to factors influencing achievement, Konvalina, Stephens and Wileman (1983:107) state:

"But knowledge of those factors influencing achievement, either by themselves, or in conjunction with those influencing aptitudes, is clearly more valuable [than aptitude alone]."

This, then, provides the impetus for additional investigations giving further information relative to factors influencing achievement in computer science. This investigation provided some of the additional information needed.

Statement of the Problem

The general area of concern of this study was: Is there a relationship between learning style and achievement in beginning computer programming classes?

In order to look at this concern in greater depth, data were collected and analyzed as part of this study:

1. to determine if achievement in beginning computer programming classes is a function of learning style as well as other selected factors;

2. to determine if student learning style changes or is modified after experiencing beginning programming instruction and, if such changes exist, whether they are related to achievement.

The students involved in the research above were those found in all sections of Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education, classes offered at Montana State University in Bozeman, Montana during Winter Quarter 1984.

Need For the Study

This investigation was needed for the following reasons:

1. There has been a call for more research in the area

of learning style and achievement in general education by Dunn and Price (1980) and Hunter (1980), and in computer science education by Konvalina, Stephens and Wileman (1983). Hunter (1980:83) reported that, "...research affirms that while learning style assessments provide an excellent diagnostic tool for counseling and individualizing instruction, the identification of the achiever has not been significantly clarified." Regarding computer science, Konvalina indicated the relative lack of research with regard to factors predicting achievement was a serious problem. This investigation will add data to this area of concern.

2. Rubenzer (1982) pointed out that learning to use the computer, particularly in the programming area, relies heavily on a sequential, orderly, and analytical style which relates well to the concepts and theory upon which the Gregorc Style Delineator (1982) is based. Additionally, the investigator found no research relating learning style to the area of computer science, particularly beginning computer programming. This investigation provided data relative to this area.

3. The Gregorc Style Delineator (1982) is a relatively new instrument. No studies utilizing this instrument were discovered in an extensive review of the literature. This investigation provided information utilizing the Gregorc instrument. (The Style Delineator

published in 1982 is a revision of the Gregorc Transaction Ability Inventory published in 1978.)

4. During the investigator's experience as a lab instructor and tutor for Elementary Education 451, Computers in Elementary Education, there appeared to be some students struggling with the content, but without the serious consequences becoming apparent until mid-way through the quarter. A way needed to be found to identify these "high risk" students earlier in order for them to receive more effective help and appropriate counseling. This investigation provided data in this area.

5. Schmeck (1983:273), in discussing learning style of college students, states, "Also, it is my bias that we need more research concerned with the modifiability of learning styles." Dunn (1983) reports that a study by Copenhaver verified that student's style remains constant regardless of the subject being studied. Expressing a contrary opinion, Cornett (1983:12) states, "While learning style has been defined as a consistent pattern of behavior, it does change with age and experience (emphasis added)." As Cornett (1983:19) goes on to say, "...we should encourage the 'flexing' capabilities of both teachers and students. The process of having students generally become more adept at adjusting learning style to teaching style and task has been labeled 'learning-to-learn'." Further, Jenkins (1981a:3) states, "Some researchers feel that ways of learning persist

even if goals and content changes (sic), while others feel they vary according to subject matter and maturity." And finally, Lassan (1982), in her doctoral dissertation concerning college nursing students as seniors, indicated that the students tended to be more able to learn by a variety of methods rather than by assuming a permanent learning style. It would be well to point out, however, that Lassan may be confusing the concept of methods with learning style -- concepts that are not necessarily identical.

The needs expressed above resulted in this investigation including a major component that addressed modification or change of learning style that may occur after experiencing beginning programming instruction.

General Questions to be Answered

The following questions, grouped into two parts, were used to guide this reasearch. The questions concerned with part 1 of the problem statement were:

1. Is achievement in beginning computer programming classes different as a function of student learning style?
2. Is achievement in beginning computer programming classes different as a function of student learning style and course content?
3. Is there a factor or combination of factors selected from learning style, age, sex, high school

performance, computer science education, formal programming experience, non-programming experience, computer programming ability, access to computers, years of high school mathematics, college grade point average (GPA), number of college mathematics courses, college class level, and academic major which predicts achievement in beginning computer programming classes?

The questions concerned with part 2 of the problem statement are:

4. Is learning style affected by experiencing beginning programming instruction?

5. Does the content emphasis of beginning computer programming classes affect learning style?

6. Is achievement in beginning computer programming classes different as a function of student learning style change between the beginning of instruction and the end of instruction?

General Procedure

In order to conduct this investigation, it was necessary to get the instructors' permission allowing the investigator access to the Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education. This permission was obtained.

In order to answer the general questions, the Gregorc Style Delineator was administered to students in Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education, classes at Montana State University, Bozeman, Montana. The instrument was administered twice during Winter Quarter 1984 -- during the first week of instruction and during the last week of instruction. Students were asked to self-report additional information on a separate questionnaire attached to the Gregorc instrument. The additional information involved student name, student identification (ID) number, selected course history, achievement history and additional demographic factors. With the exception of student ID number and name, this information was only requested during the first administration of the Gregorc instrument. Since Elementary Education 451, Computers in Elementary Education, only reported achievement with letter grades, achievement for all classes was based on letter grade.

The data were collected, compiled and analyzed. The results will be presented in Chapter 4. Chapter 5 will contain the summary, conclusions, and recommendations.

Limitations and Delimitations

Limitations

This investigation was limited as follows:

1. Student absences affecting the data base could not be controlled.

2. Course content was as indicated by the 1982-84 Undergraduate Bulletin of Montana State University as follows:

Computer Science 101, Introduction to Scientific Computing

Algorithms, flowcharts and computer programs. Interactive programming using high level languages. Programming examples and numerical techniques chosen primarily from mathematics, science and engineering.

Computer Science 111, Introduction to General Computing

Algorithms, flowcharts and computer programs. Interactive programming using high level languages. Programming examples and numerical techniques in social sciences and business. Intended for students outside of the physical sciences and engineering.

Elementary Education 451, Computers in Elementary Education

Methods and materials for developing, evaluating and using educational programs with computers in an elementary education setting. Emphasis will be on appropriate use of computers in education.

3. Due to the early demise of the original instructor of Computer Science 101, Section 01 and Computer Science 111 approximately two weeks into the quarter, two new instructors were hired to handle the two computer science classes. Effects to students as a result of this event could not be controlled and were not assessed.

Delimitations

The following delimitations were noted:

1. The population of this investigation was those students in Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education, during Winter Quarter 1984 at Montana State University, Bozeman, Montana willing to participate as indicated by proper completion of the learning style instrument.

2. No information was obtained on instructor teaching style.

Definition of Terms

The following terms were important to this investigation and needed to be defined:

1. Learning style refers to the six categories assigned to students as a result of the scores received on the Gregorc Style Delineator.

2. Gregorc Style Delineator stands for the instrument and theory developed by Anthony Gregorc based on a phenomenological approach in which a person's thinking emphasis of abstract versus concrete and ordering emphasis of sequential versus random leads to preference for learning style behaviors. Each of the four scores on the Gregorc Style Delineator range from low (10-15) to medium (16-26) to high (27-40) and represent the scales: concrete sequential (CS), abstract sequential (AS), abstract

random (AR), and concrete random (CR). Individuals will receive a score in any of the ranges given above on each of the scales. (Consult the Gregorc Style Delineator: Development, Technical and Administration Manual for further details about each category.)

3. Multiple, as used in the two-way analysis of variance and chi square 6 by 6 matrix analyses meant those individuals with more than one high score (27-40) on the Gregorc instrument.

4. Pointy-headed stood for those individuals having only one high score of 27 or higher or a score that is five points greater than the next highest score of 27 or more points on the Gregorc Style Delineator.

5. Beginning computer programming instruction meant the instruction that was presented in Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education.

6. Type of course meant the course that students were assigned to -- Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; Elementary Education 451, Computers in Elementary Education. This term was considered synonymous with course content.

7. Course content was defined as that content emphasis as found in the following three classes:

(a). Computer Science 101, Introduction to Scientific Computing, represents an introductory programming course with mathematics, science and engineering content emphasis.

(b). Computer Science 111, Introduction to General Computing, represents an introductory programming course with social science and business content emphasis.

(c). Elementary Education 451, Computers in Elementary Education, represents an introductory educational applications programming course.

7. Demographic factors refer to the student self-reported data concerning sex, age, and class and the academic major as determined by the investigator from Montana State University data files.

8. Selected course history refers to student self-reported data concerning the number of years of computer science education, number of years of non-programming computer work, number of years of formal programming work, computer access, computer programming ability, number of years of high school mathematics and number of college mathematics courses.

9. Achievement history refers to high school performance as given by self-reported cumulative letter grade average and college cumulative GPA.

10. Programming course achievement refers to the end-of-course letter grade.

Summary

The investigator conducted a study involving students enrolled in Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education, classes at Montana State University, Bozeman, Montana during Winter Quarter 1984 to determine if learning style was a factor that can be used as a predictor of achievement in beginning programming courses. An additional area of concern involved the change and/or modifiability of student learning style related to achievement after experiencing beginning programming instruction.

The investigator's review of the literature clearly indicated a lack of research regarding achievement predictors relative to computer science courses and a need for further research relative to learning style and achievement.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

This chapter contains a discussion of learning style, the history of learning style, a discussion of Kolb's, Gregorc's and McCarthy's theories, a discussion of learning style relative to achievement and a discussion of learning style relative to computer science and achievement in computer science.

What Is Learning Style?Introduction

It is very difficult to come up with one good definition of learning style because of the diversity of theories behind learning style. Depending upon the type of learning style discussed, ie., cognitive, affective, physiological, or a combination of these, a different definition is found. Dunn, Dunn and Price (1977:419) point out, "However, examination of the elements that constitute learning style reveals that among the educators, psychologists, and researchers who have published studies, the definitions vary greatly."

What follows is an attempt to present the definitions

in general and specific terms as revealed by the review of the literature on learning style. No attempt will be made to comment on the relative merits of the definitions presented and no attempt will be made to present every definition associated with each particular learning style theory discussed in the history of learning style section.

Definitions

Linskie (1977) notes that learning style is related to one's personal manner of sensing, responding, organizing, and interpreting experience. As Satterly and Brimer (1977:294) pointed out after analyzing a variety of learning style definitions to 1977, "All suggest that people behave in a typical way across a variety of tasks and that such personal consistencies remain comparatively stable over time."

Gregorc (1979c:234) relating his phenomenological approach to a learning style definition concluded, "Learning style...consists of distinctive behaviors which serve as indicators of how a person learns from and adapts to his environment. It also gives a clue as to how a person's mind operates." On the other hand, Kolb defined learning style from an experiential approach when he stated:

"Since the learning process is directed by individual needs and goals, learning styles become highly individual in both direction and process.... Each of us in a more personal way develops a learning style that has some weak points and strong points (Kolb, Rubin and McIntyre, 1979:38)."

Continuing on, Kolb, Rubin and McIntyre (1979:40) also say:

"...each person's learning style is a combination of the four basic learning modes [of concrete experience, reflective observation, abstract conceptualization, and active experimentation]."

In very general terms, Price (1981:223) refers to learning style as "how someone learns...."

The definition of learning style can also become complex as Davidman (1981:642) points out when referring to the Dunn work definition of "the manner in which at least 18 different elements from basic stimuli affect a person's ability to absorb and retain [information]." The Dunks themselves imply that learning style describes how learners are affected by four main stimuli. Dunn and Dunn (1978:4) report:

"Research data yield at least 18 categories that, when classified, suggest that learners are affected by their (1) immediate environment (sound, light, temperature, and design); (2) own emotionality (motivation, persistence, responsibility, and need for structure or flexibility); (3) sociological needs (self, pairs, peer, team, adult, or varied); and (4) physical needs (perceptual strengths, intake, time, and mobility)."

Speaking to the issue of process, four definitions are worth noting. Ribich and Schmeck (1979:516) conclude that "the concept of 'learning style' refers to the pattern of processing activities which the individual typically engages in during learning." Schmeck (1983:244) adds that "...learning style is a pattern of information-processing

activities used with some consistency to prepare for future test events." Further, Jenkins (1981:1) in her paper to the annual meeting of the National Academic Advisors Association said that "learning style is the way people process information and the way they solve problems." She went on to say, "your learning style is also determined by the way you take note of your surroundings, how you seek meaning, how you become informed (1981:2)." Another definition relative to process was expressed by Melvin in a presentation to the Association for Educational Communications and Technology, Research and Theory Division. When speaking of Kolb's work, Melvin (1982:3) said, "Learning style refers to an individual's characteristic mode of gaining, processing, and storing information during an educational experience."

Changing the notion to one of preference, Fizzell (1982:2) indicated to the Midwest Association of Teachers of Educational Psychology that, "at the simplest level, we may view learning style as one's preferred way of doing things related to learning." Munroe (1983:5,14) clarifies Fizzell's definition by stating:

"Learning style refers to the method of introducing material and points to the need to gear instruction to learner strengths.... Style refers to one's preferred manner of making meaning.... Learning or thinking styles refer to the way individuals process and arrange information and experiences to give those opportunities meaning."

Another direction of definitions seems to be along the lines of behavior.

This behavior notion is best summarized by Cornett (1983:9) when she said, "Essentially, learning style can be defined as a consistent pattern of behavior but with a certain range of individual variability.... Styles then are overall patterns that give general direction to learning behavior."

As can be seen by the variety of definitions, a common framework or composite definition is difficult to come up with; however, an extensive and complete definition has been provided by the National Association of Secondary School Principals Task Force (Keefe and Languis, 1983:1):

"Learning style is that consistent pattern of behavior and performance by which an individual approaches educational experiences. It is the composite of characteristic cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment. It is formed in the deep structure of neural organization and personality which molds and is molded by human development, and the cultural experiences of home, school and society."

This complexity of the definitions is explained when the history of learning style is examined -- the next topic of discussion in this review.

History of Learning Style

As was pointed out earlier, any review of learning style is complex. Thus, even though the term "learning style" was coined within the last 25 years, concepts involving the hows and the ways of learning have been around much longer. However, the biggest impetus for the term "learning style" has been in the last decade with the work of Dunn and Dunn (1978), Kolb (1979, 1984), McCarthy (1982), and Gregorc (1982a,b). Conceptually, however, the idea has been around for quite awhile.

The biggest problem with a review of learning style concerns the numerous definitions and instruments associated with the term. This renders any attempt to reach a convergence of the ideas virtually impossible. Divergence (Ferrell, 1983) has been the case as will be seen in the general history section that follows.

This section provides some commonality in the theories espousing learning style or a relationship to learning style. Prominent researchers and their respective theories will be presented with no attempt being made to include all researchers. Many others have conducted research based upon the work of the researchers included herein but will not be discussed.

General History of Learning Style

The origins. Human learning has long been of concern, particularly to educators. Also, depending upon one's definition of learning style, references to concepts relative to learning can be found in ancient history.

The philosophers of ancient Greece and Rome had much to say about learning, a great deal of which still pervades today's work in the fields of education and psychology. Claudia Cornett (1983) indicates that Aristotle's mnemonic techniques are still in use. Cornett goes on to state that the Greeks' temperaments classifications led to much of the personality type work during this century.

Cornett also said that during the latter part of the 19th Century, calls for individualization of instruction by university presidents such as Charles Eliot of Harvard only echoed the views of many educators such as Pestalozzi, Rousseau and Comenius in expressing their concern for the uniqueness of an individual. Out of this historical foundation has come the recent framework of learning style theory -- a framework that may represent an answer to the recent emphasis on individualization of instruction!

But when did the concept of learning style begin?

Spoken of indirectly by the early philosophers, an interest and concern of the psychologists of the late

nineteenth and early twentieth centuries and confounding educators throughout time to the present, the major development of learning style really began with the increased prominence given to the field of psychology in the twentieth century.

Those people who are psychologists refer to personality types and cognitive styles while those people concerned primarily with education seem to refer to the concept of learning style. Thus Eiszler (1983) points out that Witkin's research of the 1950's relative to psychological differentiation resulted in the term "cognitive style". Eiszler goes on to refer to articles by Riesmann and Nations giving rise to the term learning style, if not the concept.

Much research has been conducted relative to cognitive style. As Beth Davey (1983:66) puts it:

"Among the most frequently discussed dimensions of cognitive style are field independence, conceptual tempo, categorizing style, risk-taking, cognitive controls, scanning behaviors, and breadth of categorizing."

According to Keefe (1979) consideration of cognitive style has expanded to include the sensory modality preferences of kinesthetic, visual, and auditory. He also points out that current efforts concerning learning process reflect two lines of research -- applied models of learning style and strong preference for the cognitive style dimension. The work of Hunt (1981), Hill (1971), Dunn and Dunn (1978), Price (1981), Spielberger (1972), and Rotter (1966, 1971)

reflect the applied model. The strong cognitive preference is represented by the work of Kolb (1976, 1984); McCarthy (1979); Gregorc (1982); Messick (1976); Sperry (1972); Witkin (1950); Holzman and Klein (1954); Gardner, Jackson, and Messick (1960); Kagan, Moss, and Sigol (1963); Bierl; Harvey; Scott; and Bruner.

Within these two general research avenues, three dimensions or aspects of learning style can be distinguished.

Aspects of Learning Style

As evidenced by the National Association of Secondary School Principals (NASSP) definition of learning style, three aspects of learning style are delineated. The theories seem to center around either a cognitive, affective or physiological basis, or a combination of the three (Keefe, 1979). Each of these aspects or dimensions of learning style will be described and then the prominent research within each dimension will be presented. While this may not provide a chronological history as such, it does represent a discussion in which the major research is presented within each of the three dimensional categories -- cognitive, affective, and physiological.

No attempt has been made to judge any of these theories nor has there been a deliberate attempt to exclude any theory except where present researchers use past theories

with little or no modification.

The discussion will begin with the first of the three aspects of learning style mentioned -- cognitive.

Cognitive Aspects of Learning Style

According to Cornett (1983:9), "the cognitive aspect includes the ways we decode, encode, process, store and retrieve information." Items commonly included here fall into several paired continua with the characteristics represented by "opposites". Individuals are able to function along the continua in varying degrees. Along these lines then, Messick (1976:147) developed the following multiple definition of cognitive style:

"(1) [as] personal characteristics that may interact with treatment variables to moderate learning, retention, and transfer; (2) as dispositions to be monitored to detect any possible undesirable side effect of instruction; (3) as qualities to be fostered either directly or indirectly as by-products of other efforts."

What follows is a summary of cognitive learning styles selected from Keefe (1979) and as expanded by the investigator. The topics include articulation, scanning, perceptual modality preference, conceptualizing styles, conceptual tempo, cognitive complexity versus simplicity, understanding level, neurological basis, what the investigator calls the quaternary approaches, cognitive style mapping, and information processing.

Over the years, cognitive style is perhaps the

dimension of learning style that has been given the most emphasis and seen the most work. Research relative to cognitive style had been conducted for years prior to researchers' use of the term "learning style." Perhaps the most well-known is Witkin's work relative to cognitive style -- field articulation.

Field articulation. Witkin (1950, 1962, 1978) described the terms field independence and field dependence. Field dependence describes "global perceptions" in which the overall effect is the dominance of the field upon the person thus their overall difficulty in disembedding figures. To disembed a figure means that a person can locate a simple figure within a complex figure. Field independence refers to perceiving in which aspects of the field are separate (independent) from the field. Individuals with field independence readily disembed figures. These figures are the basis of the Embedded Figures Test developed by Witkin, et al (1971). The time it takes to disembed a figure becomes the score on this test.

Many other researchers have taken off from and expanded upon Witkin's original notions. Three worth noting are the concepts of constricted - flexible control, tolerance for unrealistic experiences, and leveling - sharpening developed by Gardner, Jackson, and Messick (1960).

Constricted versus flexible control. This continuum refers to the influence of distractions on task concentration. One's control is restricted if distractions keep the person from functioning properly.

Tolerance for unrealistic experiences. This cognitive style involves a preference for conventional ideas and reality or the opposite.

Leveling vs. sharpening. In the leveling versus sharpening continuum, levelers tend to over-generalize in memory processing while sharpeners tend to over discriminate.

Another theory closely related to the leveling - sharpening continuum is scanning.

Scanning. Keefe (1979) refers to the work of Holzman and Bruner in discussing scanning in which a person's deployment of attention may be labeled scanning (broad) or focusing (narrow). Many other researchers have expanded on this area.

A natural follow-up to this style is that of Pask's understanding level.

Understanding level. Gordon Pask (1976) has developed an interesting theory relative to understanding. He refers to two learning strategies and associated learning styles. One of the strategies is holist, manifesting a

style called comprehension learning in which the person may tend to be so global as to over-generalize a situation. The opposite strategy is that of serialist, manifesting a style called operation learning in which the person is so wrapped up in details that the "whole picture" is lost. Pask states that using a combination of the two leads a person to a very high level of understanding.

How individuals understand experience and classify objects provides the basis of the next two cognitive styles to be discussed -- perceptual modality preference and conceptualizing styles.

Perceptual modality preference. Sperry (1972) speaks of three modes for understanding experience -- kinesthetic or psychomotor, visual or spatial, and auditory or verbal. Children tend to be kinesthetically oriented. But as they grow older, children become more visually oriented. Adolescents prefer the verbal modality. Adults generally use all three modes with no clear preference.

Conceptualizing styles. Kagan, Moss, and Sigol (1963) distinguish three categories of conceptual styles -- analytic descriptive, inferential categorical, and relational. Analytic descriptive individuals classify objects together based on their shared characteristics (has four legs). Inferential categorical individuals group

because of categories (wooden furniture). Relational individuals group things together functionally (dogs are used to drive sheep). (Onyejiaku, 1982)

Responding and information processing provide the basis for the next two cognitive styles to be discussed -- conceptual tempo and cognitive complexity.

Conceptual tempo. Kagan (1966) refers to a reflection - impulsivity continuum where impulsives give the first answer they think of whereas reflectives consider alternatives before responding.

Cognitive complexity vs. simplicity. The number of dimensions used to process information leads to complexity or simplicity. "A high complexity style is multidimensional and discriminating, attuned to diversity and conflict. A low complexity style prefers consistency and regularity in the environment.... Harvey and his colleagues refer to this dimension as abstract versus concrete (Keefe, 1979:10)."

Neurological basis. Another area that has recently opened up relates hemispheric functioning to learning style. Rubenzer (1982), reporting on a conversation that he had with E. P. Torrance on August 12, 1982, indicated that learning style profiles developed by Torrance are expressed in terms of left, integrated or right brain preferences. This is a promising area of learning style research that is

just in its infancy.

Indeed McCarthy, a developer of one of the three quaternary approaches to be discussed next, has incorporated this right brain - left brain concept into her theories.

Quaternary Approaches

Three cognitive approaches include a quaternary format based on a design developed by the psychologist Carl Jung. These approaches include several aspects of the cognitive learning style already discussed previously, and, therefore, don't neatly fit into any one category. Because of their length, the investigator has placed them into their own main section of this chapter. These three theories are the works of David Kolb, Anthony Gregorc, and Bernice McCarthy.

Kolb's experiential model. Kolb speaks of a quadrant system which represents concrete (CE) versus abstract (AC) on the vertical axis and active (AE) versus passive (RO) on the horizontal axis. The result is that people cycle through four different learning modes as they solve problems -- concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). Each quadrant is labeled and purports to represent the attributes of individuals whose primary preferences lie in that quadrant -- diverger, assimilator, converger, and accommodator (Kolb, Rubin, and McIntyre, 1979; Kolb, 1984). (See Figure 2 for a

diagram of this experiential model.)

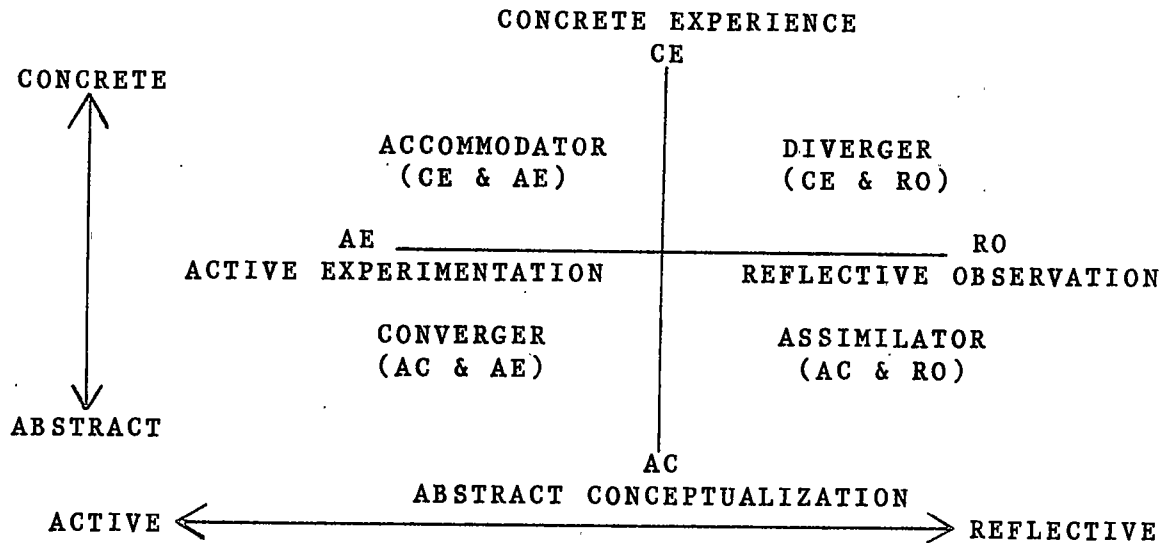


Figure 2. Kolb's Experiential Model Learning Style Quadrants

A quaternary model seemingly related to Kolb's model just discussed is that of Gregorc, the second of three quaternary approaches to be considered.

Gregorc's phenomenological model. Gregorc's work is based on the initial phases of learning in what he calls the "information acquisition phase". He also refers to a duality of abstract versus concrete relative to thinking and an ordering duality of sequential versus random (Gregorc and Ward, 1977). Gregorc (1979a) also refers to the use of multiple approaches in teaching presentations so that students learn to "stretch" and/or cope with demands and styles not their own.

According to Gregorc (1979c:19), the phenomenological viewpoint:

"...consists of distinctive and observable behaviors...that 'tell' us how [our] minds relate to the world...reflecting specific mind qualities...[that] serve as mediators as we learn and act on our environment...they are manifested as behavior and register in our conscious minds as preferred means of learning and teaching."

Gregorc (1979c:20) goes on in the same article to say that "people learn both through concrete experiences and through abstraction. Further, both of these modes have two subdivisions, sequential and random preferences."

Continuing, Gregorc (1979c:25) says, "Learning style consists of behaviors which give us clues to the mind-qualities an individual uses to interact with his environment and to gather and process data from it." Thus Gregorc developed a quadrant approach that incorporates these ideas. He describes four constructs -- concrete sequential, abstract sequential, abstract random, and concrete random. (See Figure 3 for a diagram of this phenomenological model.)

The last quaternary approach to be discussed is McCarthy's 4MAT system, which is based upon Kolb's model.

McCarthy's 4MAT model. Bernice McCarthy has taken Kolb's work and applied concepts relating right-left brain hemispheres to it. In her discussion of cognitive learning style, Cornett (1983:9) says, "Much of a person's cognitive

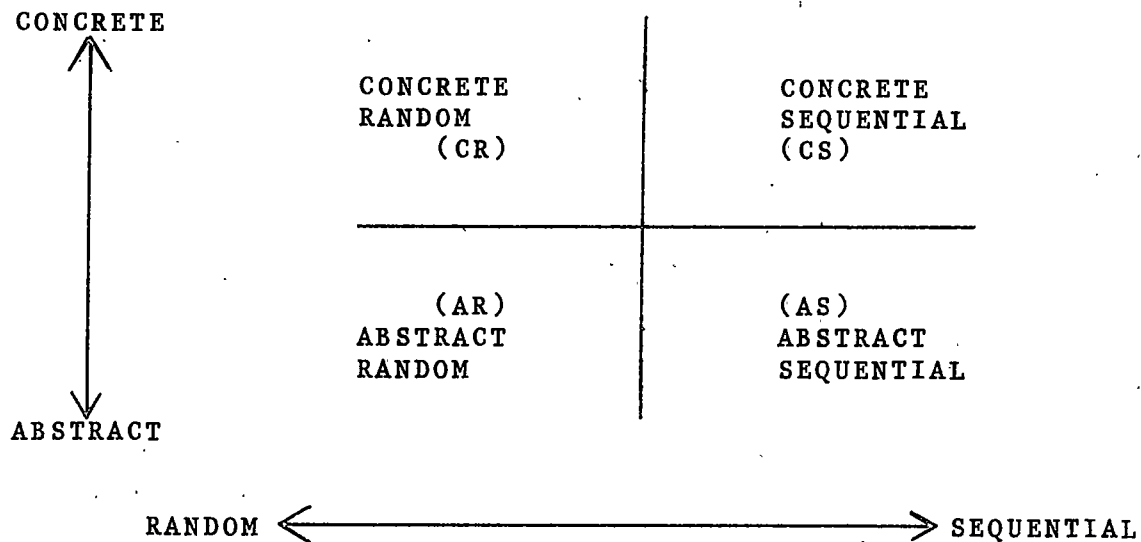


Figure 3. Gregorc's Phenomenological Model Learning Style Quadrants

learning style can be related to hemispheric brain functioning with processes falling to either the right or left hemisphere." McCarthy's quadrants are based on a vertical axis of sensing - feeling versus thinking and on the horizontal axis of doing versus watching. McCarthy, in an interview with Lefler (1983), states that scores in the various quadrants indicate preferences, not actual skills. McCarthy (1982) goes on to label the four types of learners assigned to the four quadrants as Innovators or Type I Learners (Kolb's divergers), Analytic or Type II Learners (Kolb's assimilators), Common sense or Type III Learners (Kolb's convergers), and Dynamic or Type IV Learners (Kolb's accommodators). McCarthy (1982:20) continues to say, "My 4MAT System describes a method of

teaching that includes the needs of all four main learning styles, while using right and left mode techniques."

The main difference, although subtle, between McCarthy's approach compared to Kolb's approach lies in her emphasis of teaching to all four styles causing students to style-flex as opposed to Kolb's business-oriented tie-in to problem solving strategies and managerial styles. (See Figure 4 for a diagram of McCarthy's model.)

This concludes the discussion of the first of the three aspects of learning style -- cognitive learning style approaches. The affective learning style approaches are discussed next.

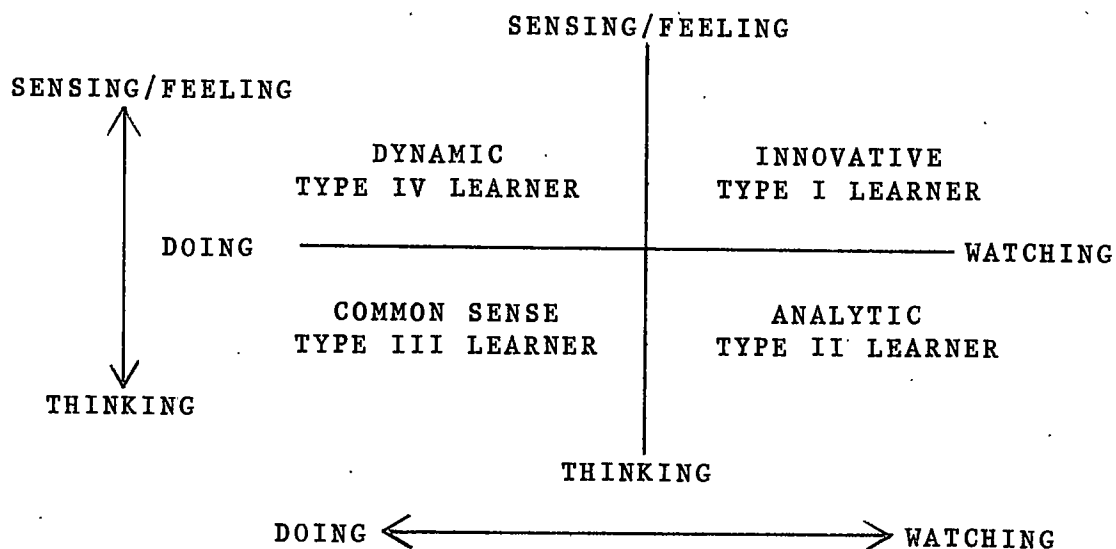


Figure 4. McCarthy's 4MAT Model Learning Style Quadrants

Affective Aspects of Learning Style

Introduction. According to Cornett (1983:10) the "affective aspects of learning style include emotional and personality characteristics related to such areas as motivation, attention, locus of control, interests, willingness to take risks, persistence, responsibility, and sociability." The definition of affective style is best described by Keefe (1979:11-12) when he states:

"Affective style is the result of a network of motivational processes that are subject to a wide variety of influences. The learner is affected by the cultural environment, parental and peer pressures, school influences and personality factors. Values are involved...[and] accustomed habits may prove to be at odds with the school values."

Relative to the affective learning style, the investigator has chosen the following affective styles listed by Keefe (1979) as most pertinent to this review of learning style -- conceptual level, curiosity, persistence, level of anxiety, locus of control, achievement motivation, risk taking, and personal interests. What follows is a brief description of each of these affective learning styles beginning with conceptual level.

Conceptual level. Within this category, Hunt (1981) says that learning style is described in terms of the structure that the student requires to learn best. Hunt (1979) further delineates the dimension of conceptual level

(CL) as nothing more than increasing responsibility. Thus a person with high CL requires low structure because they have a high degree of self-responsibility. The low CL person requires high structure.

Related to the Hunt work is the Dunn, Dunn, and Price (1979) work on structure which to them was nothing more than the number of specific rules established for working on and completing an assignment. They also discuss another factor called responsibility under which is discussed the concept that students will be more responsible when they realize that their efforts will produce success.

The next three affective learning styles to be discussed involve curiosity, on-task behavior and anxiety, respectively.

Curiosity. This affective learning style involves the attraction, in varying degrees, to the unusual, different, or discrepancies in the environment as described by Montessori (1912).

Persistence. According to Dunn, Dunn and Price (1979), some students work on a task until completed while others, known as students having "short attention spans", cannot stay on task for any length of time. The longer a student stays on-task, the more persistent they are. This category is basically on-task behavior.

Level of anxiety. Spielberger (1972) discusses

anxiety state (A-state) and anxiety trait (A-trait). According to Spielberger, high levels of A-state are experienced as unpleasant and may cause cognitive or motor responses to surface that effectively reduced A-states in the past. Individuals with high A-trait appear more threatened when their individual adequacy is evaluated than do low A-trait individuals. Relative to testing, high test-anxious students' performance seems to be decreased by the testing situation whereas low test-anxious students seem to be helped.

The next two affective learning styles, locus of control and achievement motivation, involve intrinsic and extrinsic control or intrinsic and extrinsic rewards, respectively.

Locus of control. Rotter (1966, 1971) discusses this behavior as a continuum of internal control versus external control. Persons high in internal control assume they are responsible for their own behavior and the circumstances around them. Persons high in external control tend to blame fate and thus see the circumstances as beyond their control.

Achievement motivation. This area is probably the most researched affective style and represents the work of McClelland and Alschuler. According to Keefe (1979), this affective style involves the motive used by individuals in

striving for excellence. Individuals high in achievement motivation are interested in striving for excellence for its internal rewards, not for some tangible rewards it might bring.

A person's risk-taking style and interests provide the basis for the last two affective styles to be discussed -- risk-taking and personal interests.

Risk taking. This involves a person's willingness to take chances. High risk takers prefer low probability of success and high payoff which is just the opposite for the low risk takers. According to Keefe (1979), the main contributors to this research area are Kogan and Wallach.

Personal interests. According to Witty, Freeland, and Grotberg (1966:40), interest is a disposition or tendency which causes a person to seek out particular goals for persistent attention. The corollary is that when a child is interested in something, the child will tend to favor it and thus work on it.

This concludes the consideration of two of the three aspects of learning style -- cognitive and affective. What follows is a discussion of the last aspect of learning style, that being physiological learning style.

Physiological Aspects of Learning Style

The last major grouping involves the physiological

styles, which, according to Cornett (1983:11), include sensory perception (visual, auditory, kinesthetic, taste, and smell), environmental characteristics (noise level, light, temperature, room arrangement), need for food during study, and times of day for optimum learning. What follows is a summary of the highlights in this area that includes intake, time rhythms, mobility, and the four environmental factors of sound, light, temperature, and design. All are based on the work of Dunn, Dunn and Price (1977, 1979) and are included in their Learning Style Inventory.

Intake. This is a physical item that involves taking something into the body, whether it be food, drink or cigarettes.

Time. Time of day affects student performance in that some students perform tasks better at one time of the day while others work best at just the opposite time.

Mobility. The best description here would be the term "restless students". The more mobile a person is, the more that person must move around or change positions.

Sound. Sound refers to the relative quietness of the environment. Some students require noise while others must have it completely quiet.

Light. A student can also be sensitive to light.

While most students are unaffected by normal light variations, some students can't work without bright light and vice versa.

Temperature. Temperature refers to the relative warmth or coolness of the environment. Some students prefer to be warm while others prefer to be cooler while working.

Design. The formality present in the environment is referred to as design. An informal environment would include carpet, pillows, soft chairs, etc. while a formal environment might have tile, hard chairs, library type tables, etc.. Students vary in their preference as to the design of their work environment.

There are two other major learning style theories that must be a part of this review but include combinations of the cognitive, affective and physiological aspects of learning style. These multidimensional approaches will be discussed next.

Multidimensional Approaches

Two other learning style theories do not appear to clearly fall into one of the three aspects of learning styles. These theories include cognitive style mapping (Hill, 1971; Kusler, 1979) and information processing (Schmeck, 1983). Dunn, Dunn, and Price's (1977, 1979) work falls into this category; however, their work was easily dissected and was presented earlier in this chapter under

the various affective and physiological styles.

Cognitive style mapping. One aspect of learning style research which cannot be overlooked involves the cognitive mapping work of Hill (1971) and Kusler (1979). Hill developed cognitive mapping as a diagnostic tool to lead to prescriptive education. According to Kusler (1979:92), Hill describes 28 learner characteristics which fall into three major groups: how the student takes in and processes stimuli and information, how the student's learning is affected by others, and how the student reasons to conclusions. These characteristics are then categorized as major, minor, or negligible influence. From this, a "prescription" is developed to help fit methods and materials to the student and to help the student seek learning strategies best suited to his/her style.

It appears that Dunn, Dunn and Price's work is an outcropping of this multidimensional approach to education, or, at the very least, developed concurrently. Specifically Dunn (1983) stated that 21 elements classified into stimuli of environmental, emotional, sociological, physical, and psychological have been discovered thus leading to a prescription for a student on how he/she learns best. Jenkins (1981a) reports that Nancy Dixon, working with the Dunns, has developed her own Prescription for Learning instrument.

Information processing. This work is best represented by the work of Schmeck (1983) carried out under the assumption that learning style is a pattern of information processing activities used in the preparation for future test events.

Schmeck (1983:244,270-273) described four factors relative to information processing -- Deep Processing, Methodical Study, Fact Retention, and Elaborative Processing. A student scoring high on Deep Processing seems to imply the student is very conceptual and categorizing. The student also critically evaluates, compares and contrasts the categories developed. A student scoring high in Methodical Study has organization, planning, scheduling and meticulous performance of study skills as specified in the old how-to-study manuals. Scoring high in Fact Retention implies the student has a predisposition to process details and specifics. The student with a high score in Elaborative Processing is personalizing and concretizes information by translating it into his or her own practical applications.

Learning Style Future

The diversity of the learning style theories should be very evident by this time. As Thomson (1982:222) points out, "a major need now exists to consolidate and simplify this [learning style] instrumentation so that it can be

applied in school settings." He goes on to indicate that a comprehensive practical instrument must be formed that addresses all three aspects of learning style -- cognitive, affective and physiological.

As of this writing, no researcher has yet accomplished this although the Dunns are apparently working on a psychological component to be added to their learning style instrument. When this is satisfactorily accomplished, their instrument could possibly provide the comprehensive practical instrument Thomson indicated was necessary.

As Keefe (1982:53) so aptly puts it, "Learning styles diagnosis is unquestionably a primary component of the teaching-learning cycle, one that opens the door to a personalized approach to education."

The various aspects of learning style history have now been discussed in some detail. The last two sections of this review involve the topics of learning style relative to achievement and learning style related to computer science.

Learning Style and Achievement

Statements about student achievement relative to learning style seem varied. Some researchers suggest that it is the teacher's style matching the student's style that is the biggest factor towards achievement, but others report that there is no evidence linking learning style to achievement.

For instance, Griggs (1983) indicates that the greater the match between teaching styles and student styles, the higher the grade point average. Cavanaugh (1981) indicated that in his school district which utilizes the Dunn and Dunn work, teachers report the learning styles approach has improved academic achievement and attitude. Carbo (1983:56) stated that, "Research indicates that student achievement is affected by five major learning style stimuli: environmental, emotional, sociological, physical, and psychological." She went on to develop the Reading Style Inventory based on the Dunn and Dunn model. Dunn (1983:60) refers to Domino's work and reports that:

"...students who had been exposed to a teaching style consonant with the ways they believed they learned scored higher on tests, fact knowledge, attitude, and efficiency of their work than those who had been taught in a manner dissonant with their orientations."

Expressing a contrary opinion, the authors of two doctoral dissertations completed within the last two years report that there was no significant relationship between learning styles and achievement. Mehdikhani (1983) conducted research on 90 college students in selected mathematics and English courses. Mehdikhani utilized the Canfield Learning Styles Inventory which measures preferences in learning modalities -- affiliation, structure, achievement, eminence, content, and mode. He reported no evidence to show that teacher learning style,

teacher teaching style, and student learning style had an effect on student academic achievement as measured by end-of-course grades. Additionally, McPherson (1982) in her study of cognitive learning style of students in college introductory plant physiology classes reports sex, GPA, academic college and cognitive learning style made no significant difference in student terminal mean score in the class.

Regardless of the outcomes, the need for further study along the lines of learning style and achievement has been indicated by Dunn and Price (1980:35) when they said, "However, additional investigations need to be conducted to determine the relationship(s) between learning style and achievement."

The final portion of this review looks at the area of computer science and the relationship learning style may have with beginning computer programming.

Learning Style and Computer Science

Very little research is available relative to learning style and the field of computer science or beginning programming. Only one closely related citation was found. DuCharme and DuCharme (1982:51) stated, "Using computers to teach both programming and academic skills is most effective with children whose individual learning styles are faster or slower than other children of about the same grade level."

A poignant statement was found in the citation by Rubenzer (1982:12) where he writes, "Learning to use the computer relies heavily on a sequential, orderly, and analytical style of thinking. Hence computer skills, particularly the programming aspect, appear to be predominately left brain oriented."

It is the investigator's contention that much more needs to be done in this area as there is a definite void.

There has been no attempt by any researcher to date to look at learning style as a possible factor relative to computer science aptitude and achievement. Konvalina, Stephens, and Wileman (1983:106) state:

"An important problem in educational research is the identification of factors influencing both aptitude and achievement in computer science.... Little is known about those factors that influence student success or the high withdrawal rates common in those courses.... The results of research into these factors can be helpful in advising and placing prospective students as well as planning for their future educational needs."

In discussing the fact that most of the research found in computer science concerns those factors influencing aptitudes, Konvalina, Stephens, and Wileman (1983:107) go on to say, "But knowledge of those factors influencing achievement, either by themselves, or in conjunction with those influencing aptitude, is clearly more valuable." Konvalina, Stephens, and Wileman go on to say that factors that appear to be good predictors of computer science

achievement in college are high school performance, previous computer science educational experience and high school mathematics background. In addition, they reported that, for the University of Nebraska at Omaha students, the older the student, the higher the achievement until an age category of 35 or older is reached whereupon the achievement drops.

This, then, is the impetus for additional research that provides information relative to achievement in computer science.

Summary

Since learning style research and theories seem to be divergent (Ferrell, 1983), the investigator sought a way to provide a convergent approach to learning style from the many theories on learning style. One way was to present the various theories according to the dimensions of cognitive, affective, and physiological as stated by Cornett (1983) and Keefe (1979). Even this was not enough as theories using a multidimensional approach have been developed.

Even a single definition of learning style was very difficult due to the many varied theories involved. However, the definition provided by Cornett (1983:9) appears to be summative and applicable to all theories. She states, "... Styles then are overall patterns that give general direction to learning behavior."

As aptly put by Eiszler (1983:231):

"Regardless of its origins, the concept of learner styles has been the focus of recent attempts to identify 'accessible' characteristics of adult learners (Kolb, 1976), secondary school students (Gregorc and Ward, 1977), and elementary and middle school pupils (Dunn and Dunn, 1975)."

The investigator concentrated on the concept of learning style from the standpoint of "accessible" characteristics in the cognitive area.

Gregorc's phenomenological theory was one of three theories that utilizes "accessible" characteristics according to Eiszler (1983).

Gregorc developed a quaternary approach to learning style. In his phenomenological approach, Gregorc (1979b, 1979c, 1982a, and 1982b) referred to a duality of abstract versus concrete relative to thinking and an ordering duality of sequential versus random.

Gregorc also delineated four constructs or learning styles -- concrete sequential, abstract sequential, abstract random, and concrete random.

Rubenzer (1982) stated that the term "sequential" heavily applies in learning to use the computer. This seemed to fit, at least partially, Gregorc's ordering duality of random versus sequential. Perhaps due to the recent copyright date of 1982 on the Gregorc instrument, the investigator has found no studies to date that have used this instrument. These factors seem to point to the use of

the Gregorc instrument to investigate the area of beginning computer programming to see if learning style is a useful variable to predict achievement in such courses.

The research conducted relating student learning style to achievement appears to be inconclusive with mixed results. While most research indicates achievement improvement when learning styles are accommodated, at least two recent doctoral studies (Mehdikhani, 1983; McPherson, 1982) report no significant relationship between achievement and learning style. There appears to be some conflicting data relative to this area. Even the research team of Dunn and Price (1980) expressed a need for more research into the relationship between learning style and achievement.

Within the area of computer science, Konvalina, Stephens, and Wileman (1983) state that there is a definite void in research looking at factors that can be used as predictors of achievement in computer science. In addition, the investigator found no research available on learning styles and achievement relative to beginning programming classes. These areas need further research.

Based on the information presented in this chapter, it seems that additional research needs to be conducted in the areas of learning style and achievement, computer science and predictors of achievement, and learning style and computer science (beginning programming). This investigation provided some data in these areas.

CHAPTER 3

PROCEDURES

The general investigation area of this study was: Is there a relationship between learning styles and achievement in beginning computer programming classes?

In order to look at this area in greater depth, data were collected and analyzed as part of this study:

1. to determine if achievement in beginning computer programming classes as measured by end-of-course letter grades is a function of learning style as well as other selected factors;

2. to determine if learning style changes or is modified after experiencing beginning computer programming instruction as measured by scores on the Gregorc Style Delineator given during the first week of instruction and again during the last week of instruction, and if such changes exist, whether they are related to achievement.

The purpose of this chapter is to explain the procedures which were employed to collect, organize, and analyze the data. The first sections of this chapter will be devoted to the population description and investigation categories. The later sections will deal specifically with the methods of collecting and organizing the data, the

statistical hypotheses, the analysis of data, and a summary of the chapter.

Population Description

The population of this investigation was those students found in all sections of Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education, classes offered at Montana State University in Bozeman, Montana during Winter Quarter 1984 who agreed to participate in this study by properly completing the instrument. Utilizing these intact classes represented a random sample of all students taking Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education, courses throughout the academic 1983-1984 school year.

This group of students was deemed, by the researcher, to be representative of those students at universities similar to Montana State University taking similar courses. Students in all sections of the courses had an equal chance of participating in the study.

The instructors of each of these courses granted permission to the investigator for administration of the

instruments and for access to end-of-course grading information.

Categories For Investigation

There were six general categories of variables associated with this investigation -- type of course, learning styles, demographic, achievement history, selected course history, and programming course achievement. Programming course achievement was the dependent variable with all other categories being independent variables.

In order to address the issues raised in the introduction section, the Gregorc Style Delineator was administered to students in Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education, classes at Montana State University, Bozeman, Montana. The instrument was administered twice during Winter Quarter 1984 -- during the first week of instruction and during the last week of instruction. Students were asked to self-report additional information on a separate questionnaire attached to the Gregorc instrument relative to name, student ID number, selected course history, achievement history and other demographic data. With the exception of student ID number and name, this information was requested only during the first administration of the Gregorc instrument. Achievement

was based on end-of-course letter grade.

Controls For Irrelevant and
Contaminating Variables

To provide necessary controls for some irrelevant and contaminating variables, the following precautions were taken:

1. Both the student ID number and the name were requested to assure correct pairing of first week data with last week data.
2. The directions accompanying the questionnaire included a clear statement of confidentiality to promote honesty of response and encourage participation in the investigation.
3. Self-reported data was requested in a check-list and continuum-marking format to lessen the ambiguity of open-ended responses.
4. The self-reported check list and continuum-marking format were located on a separate page attached to the Gregorc instrument to avoid distraction in filling out the Gregorc instrument.
5. The Gregorc instrument was administered exactly as directed in the technical manual.

Data Collection

Instruments

One previously established instrument was used to collect data for this investigation -- the Gregorc Style Delineator. In addition, a simple questionnaire was attached to the Gregorc instrument that asked the student to self-report various demographic, achievement history, and selected course history information.

Applicable validity and reliability data for the Gregorc instrument follows. Gregorc reported the establishment of construct validity in the development of his instrument. Reliability of the Gregorc Style Delineator was reported in two ways: internal consistency and stability. Reporting a Standardized Alpha for internal consistency, which is nothing more than a Kuder-Richardson Formula 20 with multi-point items (Nunnally, 1970:551) and a product-moment r for stability (reliability over time), Gregorc (1982b:19) indicated the following results on the same test given to the same group on two separate occasions as:

	<u>First</u>	<u>Second</u>	<u>r</u>
Concrete Sequential	0.92	0.92	0.85
Abstract Sequential	0.89	0.92	0.87
Abstract Random	0.93	0.92	0.88
Concrete Random	0.91	0.91	0.87

Thus the reliability of the Gregorc instrument was reported to be high.

Selection of the Gregorc instrument for use in this investigation was based on three reasons. First, since the instrument has only been on the market for a short time (1982 copyright date), the investigator found no studies utilizing the instrument. More data needs to be collected using the Gregorc instrument. The second reason involved the processing duality of random versus sequential found in Gregorc's theory upon which his instrument is based. Rubenzer (1982:12) pointed out that, "Learning to use the computer... relies heavily on a sequential, orderly, analytical style of thinking." Since the Gregorc instrument contains the key word "sequential" as a part of the learning style categories it purports to measure and Rubenzer says that learning computer use requires a "sequential" thinking style, the investigator chose the Gregorc instrument for this investigation. Thirdly, the Gregorc instrument took less than five minutes to fill out. This time limit was a condition necessary for being granted access to a portion of an instructional class period as agreed to by the course instructor.

Procedures

The Gregorc instrument was administered by the investigator in the Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to

General Computing; and Elementary Education 451, Computers in Elementary Education, classes during Winter Quarter 1984. The instrument was given during the first week of instruction and again during the final week of instruction at the beginning of the class period, consuming approximately 10 minutes. However, the questionnaire information was not collected again during the final week of instruction.

If a student failed to complete or improperly completed the Gregorc instrument during one or both of its administrations, the student was eliminated from the data base.

Method of Organizing Data

Scoring

The instruments were hand scored by the investigator and the data transferred to coding sheets by the investigator for data entry by the Montana State University Computer Service. The accuracy of the data entry was further verified by the investigator before any statistical analyses were performed. The analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 9.1 (Nie, et al, 1975; Hull and Nie, 1981) as implemented on MSU's Honeywell Level 66 mainframe.

Reporting

After the data were recorded, processed and analyzed, the results were reported in written and tabular form.

Statistical Hypotheses

The hypotheses for this investigation follow. A general question will be listed followed by all of the research hypotheses that apply to that question. All null hypotheses were tested at the 0.05 level of significance.

1. Is achievement in beginning computer programming classes different as a function of student learning style?

NULL: 1. There is no difference between the mean achievement in beginning computer programming classes when compared to the learning style categories as measured by the Gregorc instrument.

ALTERNATIVE: There is a difference between the mean achievement in beginning computer programming classes when compared to the learning style categories as measured by the Gregorc instrument.

2. Is achievement in beginning computer programming classes different as a function of student learning style and course content?

NULL: 2. There is no difference between the mean achievement in beginning computer programming classes when compared to the last week of instruction learning style categories as measured by the Gregorc instrument.

ALTERNATIVE: There is a difference between the mean achievement in beginning computer programming classes when compared to the last week of instruction learning style categories as measured by the Gregorc instrument.

NULL: 3. There is no difference between the mean achievement in beginning computer programming classes relative to course content and learning style category as measured by the Gregorc instrument given during the last week of instruction.

ALTERNATIVE: There is a difference between the mean achievement in beginning computer programming classes relative to course content and learning style category as measured by the Gregorc instrument.

3. Is there a factor or combination of factors selected from learning style, age, sex, high school performance, computer science education, formal computer programming experience, non-programming computer experience, computer programming ability, access to computers, languages able to program in, years of high school mathematics, college GPA, number of college mathematics courses, college class, and academic major which predicts achievement in beginning computer programming classes?

NULL: 4. There is no linear relationship between achievement in beginning computer programming classes and the set of independent variables of learning style, age, sex, high school performance, computer science education,

formal computer programming experience, non-programming computer experience, computer programming ability, languages able to program in, access to computers, years of high school mathematics, college GPA, number of college mathematics courses, college class, and academic major.

ALTERNATIVE: There is a linear relationship between achievement in beginning computer programming classes and the set of independent variables of learning style, age, sex, high school performance, computer science education, formal computer programming experience, non-programming computer experience, computer programming ability, languages able to program in, access to computers, years of high school mathematics, college GPA, number of college mathematics courses, college class, and academic major.

4. Is learning style affected by experiencing beginning computer programming instruction?

NULL: 5. First week learning style preference is independent of last week learning style preference.

ALTERNATIVE: There is a dependency between first week learning style and last week learning style.

5. Does the content emphasis of beginning computer programming classes affect learning style?

NULL: 6. The frequency of change versus no change in learning style change categories is independent of course content.

ALTERNATIVE: The frequency of change versus no change

in learning style change categories and course content are dependent.

6. Is achievement in beginning computer programming classes different as a function of student learning style change between the beginning of instruction and the end of instruction?

NULL: 7. There is no difference in achievement as a function of change in learning style from first week to last week in beginning computer programming classes.

ALTERNATIVE: There is a difference in achievement as a function of change in learning style from first week to last week in beginning computer programming classes.

Analysis of Data

Computer analysis of the data was performed using the SPSS statistical package and included descriptive statistics, one-way and two-way analysis of variance, stepwise multiple regression, and Chi-square Test of Independence.

A 0.05 level of significance was selected as a compromise consideration for the control of Type I and Type II errors. A Type I error involves saying something did happen or has a relationship when in fact it really did not. The Type II error involves saying something did not happen or has no relationship when in fact it really did. Since the investigator felt that avoidance of both Type I and Type

II errors were important to this investigation, the investigator protected against both. The 0.05 level of significance provided the best compromise protection against both types of errors.

The statistical analysis and design was as follows:

1. Descriptive statistics were used to obtain frequency distributions of the various demographic variables and learning style instrument scores to test the accuracy of the data base and the accuracy of the statistical manipulations of the data base by the SPSS command files built by the investigator to create computed variables.

2. The one-way analysis of variance involved a one by six design to test hypotheses one and two related to question one. Both pre-learning style and post-learning style were assessed with a one by six matrix design. Pre-learning style and post-learning style scores were the independent variables and achievement, as measured by end-of-course letter grades, was the dependent variable. Figure 5 shows this design. (Ferguson, 1976:223-233)

3. The first two-way analysis of variance involved a six by four design to test hypothesis three related to question two. One independent variable (rows on the matrix) was represented by the six final week learning style categories (post-learning style) as indicated by pointy-headed scores (27 or above) as measured by the Gregorc instrument. Students identified as concrete

Pre-Learning Style

CS	AS	AR	CR	MULTIPLE	NONE
A	A	A	A	A	A

Post-Learning Style

CS	AS	AR	CR	MULTIPLE	NONE
A	A	A	A	A	A

CS=concrete sequential; AS=abstract sequential
 AR=abstract random; CR=concrete random;
 MULTIPLE=2 or more scores 27 or higher; NONE=
 no score 27 or above; A=achievement

Figure 5. One-way Analysis of Variance of
 Pre/Post-Learning Style with Achievement

sequential (CS), abstract sequential (AS), abstract random (AR) and concrete random (CR) had a single score of 27 or higher in the respective category or a score at least five points greater than the next closest score of 27 or above. Students marked MULTIPLE had two or more scores of 27 or higher. Those students classified as NONE had no score 27 or higher when the Gregorc instrument was scored. The other independent variable (columns on the matrix) was represented by the four course codes of Computer Science 101, Section 01; Computer Science 101, Section 02; Computer Science 111; and Elementary Education 451.

The dependent variable in this six by four design was achievement as measured by end-of-course letter grades. See

Figure 6 for a diagram of this design. (Ferguson, 1976:223-25,240-56)

4. The second two-way analysis of variance involved a six by six design to test hypothesis seven related to question six. One independent variable (rows on the matrix) was represented by the six first week learning style categories (pre-learning style) as indicated by pointy-headed scores (27 or above) as measured by the

		COURSE			
		CS101,01	CS101,02	CS111	EdE1451
POST LEARNING STYLE	CS	A	A	A	A
	AS	A	A	A	A
	AR	A	A	A	A
	CR	A	A	A	A
	MULTIPLE	A	A	A	A
	NONE	A	A	A	A

CS=concrete sequential; AS=abstract sequential; AR=abstract random; CR=concrete random; MULTIPLE=2 or more scores of 27 or higher; NONE=no score 27 or above; A=achievement

Figure 6. Two-way Analysis of Variance of Post-Learning Style by Course with Achievement Dependent

Gregorc instrument. The other independent variable (columns on the matrix) was represented by the six final week learning style categories (post-learning style) using the same criteria. Students marked concrete sequential (CS), abstract sequential (AS), abstract random (AR) and concrete random (CR) had a single score of 27 or higher in the respective category or a score at least five points greater than the next closest score 27 or above. Students marked

MULTIPLE had two or more scores of 27 or higher. Those students classified as NONE had no score 27 or higher when the Gregorc instrument was scored.

The dependent variable within each cell of the matrix was achievement as measured by end-of-course letter grades. See Figure 7 for a diagram of this design. (Ferguson, 1976:223-25,240-56)

		POST-LEARNING STYLE					
		CS	AS	AR	CR	MULTIPLE	NONE
PRE-LEARNING STYLE	CS	A	A	A	A	A	A
	AS	A	A	A	A	A	A
	AR	A	A	A	A	A	A
	CR	A	A	A	A	A	A
	MULTIPLE	A	A	A	A	A	A
	NONE	A	A	A	A	A	A

CS=concrete sequential; AS=abstract sequential; AR=abstract random; CR=concrete random; MULTIPLE=2 or more scores of 27 or higher; NONE=no score 27 or above; A=achievement

Figure 7. Two-way Analysis of Variance of Pre-Learning Style by Post-Learning Style with Achievement Dependent

5. Stepwise multiple regression was used to identify the factor(s) which were the best predictors of achievement to test null hypothesis four related to question three. Twenty-two variables were involved. The dependent variable was achievement as measured by end-of-course letter grades. The independent variables were learning style, age, sex, high school performance, years of computer science education, years of formal computer programming experience, years of non-programming computer experience, computer

programming ability, access to computers, languages able to program in (eight separate variables were in this category), years of high school mathematics courses, college GPA, number of college mathematics courses, college class level, and academic major. (Ferguson, 1976:455-66)

6. A Chi Square Test of Independence was utilized in the analysis of the data concerning null hypotheses five and six relative to questions four and five. The matrix design for question four had the same physical design as the two-way analysis of variance design found in Figure 7, except that frequencies replaced achievement.

The design for question five's chi square analysis was a two by four matrix with change in learning style assigned to the rows and course code assigned to the columns. Change was determined by whether the individual had the same post-learning style as pre-learning style. If the two style categories were not the same, the individual was said to have changed learning style. See Figure 8 for a diagram of this design. (Ferguson, 1976:187-205)

		COURSE			
		CS101,01	CS101,02	CS111	EdE1451
CHANGE IN LEARNING STYLE	NO	F	F	F	F
	YES	F	F	F	F

F=frequency count

Figure 8. Chi Square Test of Independence Between Change in Learning Style and Course Content

Precautions Taken For Accuracy

The investigator developed an appropriate coding scheme, hand scored the instruments, and transferred data to the coding sheets for data entry by the Montana State University Computer Service. The investigator verified the accuracy of the data transferred to the coding sheets by having the data repeated orally by another person while the investigator checked each written entry.

After data entry into the computer by the Montana State University Computer Service, the investigator checked the print out of the preliminary data with the data from the original coding sheets to verify the accuracy of the data and made any changes necessary to the data base.

Computer calculations were employed to afford greater accuracy in the statistical analysis of the data.

Summary of the Chapter

This chapter outlined the procedures that were used to determine the relationships that exist between the independent variables of learning style, achievement history, selected course history and other demographic factors as a function of the dependent variable of beginning computer programming course achievement as measured by end-of-course letter grade in college level Computer Science 101, Introduction to Scientific Computing; Computer Science

111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education, classes at Montana State University in Bozeman, Montana during Winter Quarter 1984.

The instruments used were described as the Gregorc Style Delineator and a self-report data questionnaire. The Gregorc instrument was administered twice during the quarter with the self-report data being reported only during the first administration of the instrument.

Computer analysis of the data was performed using SPSS and included descriptive statistics, one-way and two-way analysis of variance, stepwise multiple regression, and the Chi-Square Test of Independence.

CHAPTER 4

FINDINGS AND INTERPRETATIONS

Introduction

The general area of concern of this study was: Is there a relationship between learning style and achievement in beginning computer programming classes?

In order to look at this concern in greater depth, data were collected and analyzed as part of this study:

1. to determine if achievement in beginning computer programming classes is a function of learning style as well as other selected factors;
2. to determine if student learning style changes or is modified after experiencing beginning programming instruction and, if such changes exist, whether they are related to achievement.

These areas of concern led to the formulation of six questions to be answered by the investigation. To answer these questions, four types of statistical analyses were performed -- one-way and two-way analysis of variance, stepwise multiple regression and the Chi Square Test of Independence.

The different types of statistical analyses performed will be used as the major divisions of this chapter. Within

each division, the applicable general question will be presented followed by the findings reported in tabular form. The data will then be interpreted after each hypothesis and table is presented. The chapter will conclude with a summary of the investigative questions, major hypotheses and decisions made relative to the hypotheses.

One-Way Analysis of Variance

This statistical procedure involved the general question:

1. Is achievement in beginning computer programming classes different as a function of student learning style?

Two null hypotheses were formulated to answer this question with the results presented in Tables 1 and 2.

Table 1 contains the results of the one-way analysis of variance involving the learning style categories obtained during the first week of instruction (PRELS) as the independent variable and achievement, as measured by end-of-course letter grade, as the dependent variable. The PRELS variable indicated the "pointy-headed" preference of each participant in the investigation.

To be pointy-headed in a category, an individual had to have a score of 27 or more points in that category or be at least five points greater than the next higher score of 27 points or more. For example, if a person's scores were abstract sequential (AS)=27, concrete sequential (CS)=32,

concrete random (CR)=17 and abstract random (AR)=24, there would be two pointy-headed categories with scores of 27 or higher -- abstract sequential and concrete sequential. However, using the criterion expressed earlier, this individual would be assigned to the concrete sequential category because the concrete sequential score of 32 is five points greater than the abstract sequential score of 27 ($32-27=5$). The investigator felt this to be practical as this five point difference would require the participant to mark five out of ten items on the Gregorc instrument at a higher level.

The categories of responses used in the pre-learning style (PRELS) category were:

- 1 = pointy-headed concrete sequential
- 2 = pointy-headed abstract sequential
- 3 = pointy-headed abstract random
- 4 = pointy-headed concrete random
- 5 = multiple (two or more pointy-headed scores)
- 6 = none (no pointy-headed scores)

Table 1. Results from the One-Way Analysis of Variance of Pre-Learning Style (First Week Scores) with Letter Grade Achievement Dependent

COURSE CONTENT	MAIN SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	SIGNIF. OF F	N
CS101,01	MAIN EFFECTS	10.74	5	2.10	1.53	.18	141
CS101,02	MAIN EFFECTS	3.26	5	.65	.39	.85	82
CS111	MAIN EFFECTS	3.46	5	.69	.53	.75	78
EDEL451	MAIN EFFECTS	.19	2	.10	.28	.76	13
ALL	MAIN EFFECTS	4.53	5	.90	.58	.71	314

NULL HYPOTHESIS: 1. There is no difference between

the mean achievement in beginning computer programming classes when compared to the first week learning style categories (PRELS) as measured by the Gregorc instrument.

The results in Table 1 indicate that no significant difference exists between the mean achievement in beginning computer programming classes when compared to the pre-learning style categories as measured by the Gregorc instrument. The F value of 0.58 for all of the classes combined had a significance level of 0.71; therefore, null hypothesis 1 was RETAINED.

Achievement in beginning computer programming classes does not appear to be related to student learning style as measured by the Gregorc instrument administered during the first week of class.

Table 2 contains the results of the one-way analysis of variance conducted with learning style scores obtained during the final week of instruction (POSTLS) as the independent variable and achievement as measured by end-of-course letter grade as the dependent variable. The POSTLS categories were assigned in the same manner as was described for the PRELS categories from the previous one-way analysis of variance.

Table 2. Results from the One-Way Analysis of Variance of Post-Learning Style (Last Week Scores) with Letter Grade Achievement Dependent

COURSE CONTENT	MAIN SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	SIGNIF. OF F	N
CS101,01	MAIN EFFECTS	3.59	5	.71	.51	.77	141
CS101,02	MAIN EFFECTS	5.07	5	1.02	.62	.68	82
CS111	MAIN EFFECTS	3.99	5	.80	.61	.70	78
EDEL451	MAIN EFFECTS	1.69	3	.56	2.54	.12	13
ALL	MAIN EFFECTS	3.48	5	.70	.45	.82	314

NULL HYPOTHESIS: 2. There is no difference in the mean achievement in beginning computer programming classes when compared to the last week of instruction learning style categories (POSTLS) as measured by the Gregorc instrument.

The results in Table 2 indicate that no significant difference exists between letter grade mean achievement and the post-learning style categories (POSTLS) at the 0.05 level of significance. The F value of 0.45 for all classes combined only had a significance of 0.82; therefore, null hypothesis 2 was RETAINED. End-of-course letter grade achievement does not seem to be different among the student learning style categories derived from the Gregorc Style Delineator administered after completion of course instruction.

Two-Way Analysis of Variance

Two different designs were utilized to answer the following questions:

2. Is achievement in beginning computer programming classes different as a function of student learning style and course content?

6. Is achievement in beginning computer programming classes different as a function of student learning style change between the beginning of instruction and the end of instruction?

Table 3 contains the results from the two-way analysis of variance conducted in a six by four design to answer question 2. The two independent variables were learning style as measured by the Gregorc instrument during the last week of instruction (POSTLS) and course content as indicated by class membership in Computer Science 101, Section 01 or Computer Science 101, Section 02 or Computer Science 111 or Elementary Education 451. Achievement as measured by end-of-course letter grades was the dependent variable.

Table 3. Results from the Two-Way Analysis of Variance of Post-Learning Style (Last Week Scores) by Course Content with Letter Grade Achievement Dependent

MAIN SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	SIGNIF. OF F
MAIN EFFECTS	59.44	8	7.43	5.28	<.001*
POSTLS	2.56	5	.51	.36	.87
COURSE CONTENT	55.96	3	18.65	13.27	<.001*
INTERACTION	11.79	13	.91	.64	.82

* = significant beyond 0.05 level N = 314

NULL HYPOTHESIS: 3. There is no difference between the mean achievement in beginning computer programming

classes relative to course content and learning style category as measured by the Gregorc instrument given during the last week of instruction.

The results in Table 3 indicate that there is a significant main effects difference between the independent variables of last week of instruction learning style categories (POSTLS) and course content and the dependent variable of letter grade achievement. The F of the main effects was 5.28 and was significant below the .001 level. Likewise, the F of the course content was 13.27 which was also significant below the .001 level. Therefore, the null hypothesis was REJECTED in favor of the alternative which stated that there is a difference between the mean achievement in beginning computer programming classes relative to course content and last week learning style category.

It should also be pointed out, however, that the significant main effects were due to the course content variable and not the post-learning style variable which only has an F value of 0.36 and a significance of 0.87. Rejection of null hypothesis 3 adds no support to differences in achievement being a function of learning style.

Table 4 contains the results from the two-way analysis of variance conducted with a six by six design to answer question six which asked:

6. Is achievement in beginning computer programming classes different as a function of student learning style change between the beginning of instruction and the end of instruction?

The two independent variables were the first week of instruction learning style category (PRELS) and the last week of instruction learning style category (POSTLS). The dependent variable was achievement as measured by end-of-course letter grades.

Table 4. Results from the Two-Way Analysis of Variance of Pre-Learning Style (First Week Scores) by Post-Learning Style (Last Week Scores) with Letter Grade Achievement Dependent

MAIN SOURCE OF VARIATION	SUM OF SQUARES	DF	MEAN SQUARE	F VALUE	SIGNIF. OF F
MAIN EFFECTS	8.76	10	.88	.56	.84
PRELS	5.28	5	1.06	.68	.64
POSTLS	4.23	5	.85	.54	.74
INTERACTION	30.72	19	1.62	1.04	.42

N = 314

NULL HYPOTHESIS: 7. There is no difference in achievement as a function of change in learning style from first week to last week in beginning computer programming classes.

The results in Table 4 indicate that there is no difference in achievement as a function of change in learning style in beginning computer programming classes at the 0.05 level of significance. The F values of 0.56 and

1.04 for main effects and interaction, respectively, had significance values of 0.84 and 0.42, respectively; therefore, null hypothesis seven was RETAINED. Any change that occurred in learning style, as measured by the Gregorc instrument, does not appear to affect achievement in beginning computer programming classes.

Stepwise Multiple Regression

The general question to be answered by this statistical procedure was:

3. Is there a factor or combination of factors selected from learning style, age, sex, high school performance, computer science education, formal computer programming experience, non-programming computer experience, computer programming ability, access to computers, languages able to program in, years of high school mathematics, college GPA, number of college mathematics courses, college class, and academic major which predicts achievement in beginning computer programming classes?

Table 5 summarizes the results from the stepwise multiple regression for all of the courses combined -- Computer Science 101, Section 01; Computer Science 101, Section 02; Computer Science 111; and Elementary Education 451. Each of the 22 independent variables was analyzed as a possible predictor of letter grade achievement. Letter grade achievement was the criterion or dependent variable in

this stepwise multiple regression.

Table 5. Results of the Stepwise Multiple Regression for All Classes with Letter Grade Achievement as the Criterion Measure

VARIABLE NAME	BETA	F	MULT. R	² R
High School Performance	.16	3.37*	.32	.10
College Grade Point Average	.25	22.25*	.39	.15
College Class Level	.20	8.42*	.43	.19
Computer Prog. Ability	.21	5.54*	.48	.23
Yrs of H. S. Mathematics	.20	11.29*	.50	.25
Sex	.16	8.31*	.52	.27
First Week Learning Style	.08	2.06*	.52	.27
Machine Lang. Prog. Ability	.07	.93	.53	.28
Cobol Programming Ability	-.07	1.65*	.53	.28
No. College Math. Courses	.06	1.04	.54	.29
Non-Programming Experience	-.08	1.98*	.54	.29
Basic Programming Ability	-.09	1.31	.54	.29
Yrs. of Computer Sci. Educ.	.08	.59	.54	.30
Pascal Programming Ability	-.07	1.30	.54	.30
Academic Major	-.04	.49	.55	.30
Yrs. of Prog. Experience	.04	.15	.55	.30
Logo Programming Ability	.02	.08	.55	.30
Age	-.02	.08	.55	.30
Other Prog. Languages	-.01	.05	.55	.30
Access to Computers	-.01	.02	.55	.30
Fortran Programming Ability	.01	.01	.55	.30

df 21,276; Critical F=1.62 @ df 20,200 (df 20,200 was used as the only values closest to df 21,276 in the available critical F table); *=significant @ 0.05 level; N=298

NULL HYPOTHESIS: 4. There is no linear relationship between achievement in beginning computer programming classes and the set of independent variables of learning style, age, sex, high school performance, computer science education, formal computer programming experience, non-programming computer experience, computer programming ability, languages able to program in, access to computers,

years of high school mathematics, college GPA, number of college mathematics courses, college class, and academic major.

The results in Table 5 show that there are nine variables that are statistically significant that might be used to predict letter grade achievement in beginning computer programming classes. At the 0.05 level of significance, the critical F for 20 and 200 degrees of freedom was determined to be 1.62. [The actual degrees of freedom for the regression were 21 and 276, however, the most complete table of critical F's available was found in Ferguson (1976) and did not contain a critical F for df 21 and 276. The critical F for df 20 and 200 was used as it was the next lower value available.]

Table 5 also includes the beta value which is the standardized multiplier by which a specific variable's value is multiplied in figuring out predicted letter grade achievement. The beta was chosen because it incorporates the constant into its value and offers a direct comparison between variables that use different scales.

In order of their predictive ability followed by the respective F value and beta value in parentheses, the variables are high school performance (3.37, +0.16), college grade point average (22.25, +0.25), college class level (8.42, +0.20), computer programming ability (5.54, 0.21), years of high school mathematics (11.29, +0.20), sex (8.31,

+0.16), first week learning style (2.06, +0.08), Cobol programming ability (1.65, -0.07) and non-programming experience (1.98, -0.08). Therefore, the null hypothesis that there is no linear relationship was REJECTED. There are variables that seem to predict letter grade achievement. However, since only 30% of the variance can be accounted for by these variables, one could question the pedagogical significance of these findings.

It is interesting to note that the last two statistically significant predictors, Cobol programming ability and non-programming experience, have a negative, not additive effect, on letter grade prediction. The greater the amount of non-programming computer experience and that a person can program in Cobol results in the predicted letter grade being lower. On the contrary, the best predictors are high school performance and college GPA.

Another interesting point is that the higher the person's year in college, e.g., senior as opposed to freshman, the higher the achievement prediction. Likewise, the more high school mathematics taken, the higher the predicted letter grade.

Looking at the first week learning style variable, it seems that respondents that were multiple or non-pointy headed were favored over the other learning style categories in the prediction of higher achievement.

Two final comments seem appropriate here. Computer

programming ability is a variable in which the respondent was asked to rate their own perceptions of their programming ability. The results seem to indicate that the higher a person rates their programming ability, the greater their predicted achievement. Also, the fact that a respondent was female gave that person a predicted achievement edge over a male.

Chi Square Test of Independence

Two chi square designs were used to answer the following questions:

4. Is learning style affected by experiencing beginning computer programming instruction?
5. Does the content emphasis of beginning computer programming classes affect learning style?

The data is presented in the form of frequency count rather than percent frequency distributions in the chi square tables that follow.

Table 6 contains the results of the first chi square design which was used to answer question four. It involved a six by six design similar to the design of the two-way analysis of variance with first week of instruction learning style categories (PRELS) compared to the last week of instruction learning style categories (POSTLS).

Table 6. Chi Square Frequency Distribution of First Week Learning Style Categories by Last Week Learning Style Categories

FIRST WEEK STYLE	LAST WEEK LEARNING STYLE						ROW TOT.
	CS	AS	AR	CR	MULT	NONE	
CS	49	6	6	6	27	3	97
AS	5	5	3	3	11	0	27
AR	2	0	9	0	9	1	21
CR	3	0	0	11	14	1	29
MULT	26	12	14	14	64	2	132
NONE	1	0	2	2	2	1	8
COL. TOT.	86	23	34	36	127	8	314

df 4; Calculated Chi Square=100.47; Significance=<.001;
55.6% of cells with frequency <5

NOTE: CS=concrete sequential; AS=abstract sequential;
AR=abstract random; CR=concrete random; MULT=2 or more
pointy-headed categories; NONE=no pointy-headed categories

Since Ferguson (1976:201) indicated that cells with frequencies less than five seriously affect the statistical analyses and since the data in Table 6 show that 55.6% of the cells have a frequency less than five, the investigator collapsed the categories to achieve an increased cell count. This required that two new variables be created for each pre-learning style and post-learning style variable. A sequential - random preference variable was formed by combining the abstract sequential (AS) and concrete sequential (CS) into a sequential preference and the abstract random (AR) and concrete random (CR) variables into a random preference. This was done for both the pre-learning style and post-learning style variables. The multiple pointy-headed category was retained.

The second variable involved a concrete - abstract preference. To form this variable, the concrete sequential (CS) and concrete random (CR) categories were combined to form a concrete preference and the abstract sequential (AS) and abstract random (AR) categories were grouped to form an abstract preference. Again the multiple category was retained. However, since the non pointy-headed category was represented by only 2.5% of the total N (8 out of 314), it was dropped from further analysis.

Tables 7 and 8 contain the results of the collapsing of the learning style categories. This collapsing was successful and allowed further confidence to be placed in the statistical analyses since there were no cells with a frequency less than five. Table 7 contains the sequential - random preference results while Table 8 contains the concrete - abstract results.

Table 7. Chi Square Frequency Count of the Sequential-Random Preference Variable Comparing First Week to Last Week Learning Style Preferences

FIRST WEEK STYLE	LAST WEEK STYLE			ROW TOTAL
	SEQUENTIAL	RANDOM	MULTIPLE	
SEQUENTIAL	65	18	38	121
RANDOM	5	20	23	48
MULTIPLE	38	28	64	130
COLUMN TOTAL	108	66	125	299

df 4; calculated chi square=37.34; significance=<.001

Table 8. Chi Square Frequency Count of the Concrete-Abstract Preference Variable Comparing First Week to Last Week Learning Style Preferences

FIRST WEEK STYLE	LAST WEEK STYLE			ROW TOTAL
	CONCRETE	ABSTRACT	MULTIPLE	
CONCRETE	69	12	41	122
ABSTRACT	10	17	20	47
MULTIPLE	40	26	64	130
COLUMN TOTAL	119	55	125	299

df 4; calculated chi square=32.12; significance=<.001

Using Tables 6, 7 and 8, question number four, which asked if learning style was affected by experiencing beginning programming instruction, can now be answered.

NULL HYPOTHESIS: 5. First week learning style preference is independent of last week learning style preference.

Tables 6, 7 and 8 all indicate that there is a relationship between first week and last week learning style preference. The chi square values of 100.47, 37.34 and 32.12 for the respective analyses were all significant beyond the .001 level. Therefore, null hypothesis 5 was REJECTED in favor of the alternative that there is a dependency between first and last week learning style preference.

Further inspection of Tables 7 and 8 revealed that approximately 50% of the subjects did change their learning style preference. To further examine these tendencies, some additional descriptive results were computed. For each

learning style preference, frequencies were established for those individuals remaining the same, those individuals shifting preference toward and those individuals shifting preference away from a learning style category as indicated by first week and last week learning style. Relative gains and losses were computed by finding the difference between the change toward and the change away from the learning style. These results are summarized as follows:

LEARNING STYLE	SAME	CHANGE TOWARD	CHANGE AWAY	GAIN(+) LOSS(-)
CONCRETE SEQUENTIAL	49	37	48	-11
ABSTRACT SEQUENTIAL	5	18	22	- 4
ABSTRACT RANDOM	9	25	12	+13
CONCRETE RANDOM	11	25	18	+ 7
MULTIPLE POINTY-HEADED	64	65	68	- 5
NON POINTY-HEADED	1	7	7	0

Using Tables 7 and 8 which involved the concrete - abstract and sequential - random preferences, the following gain/loss summary can be formed:

LEARNING STYLE	SAME	CHANGE TOWARD	CHANGE AWAY	GAIN(+) LOSS(-)
SEQUENTIAL	65	43	56	-13
RANDOM	20	46	28	+18
CONCRETE	69	50	53	- 3
ABSTRACT	17	38	30	+ 8
MULTIPLE POINTY-HEADED	64	61	66	- 5

As can be seen from these two summaries, where there is change, it appears as if there is a trend from pre-learning style to post-learning style toward the random and abstract

preferences.

To answer question five, which asked if the content emphasis of beginning computer programming classes affected learning style, a two by four chi square design was used in which change in learning style (LSCHANGE) was compared with course content.

LSCHANGE represents a yes-no response mode; either there was a change or there was not. An individual was deemed to have changed in learning style if his/her learning style category of the first week of instruction did not match his/her final week of instruction learning style category.

Table 9 contains the results of this data analysis.

Table 9. Chi Square of Frequencies of Learning Style Change by Course Content

LSCHANGE	CS101,01	CS101,02	CS111	EDEL451	ROW TOTAL
NO	65	37	33	4	139
YES	76	45	45	9	175
COLUMN TOTAL	141	83	78	13	314

df 3; Calculated Chi Square=1.30; significance=.73

NULL HYPOTHESIS: 6. The frequency of change versus no change in final week learning style categories is independent of course content.

The results from Table 9 indicate that learning style change is independent of course content as the significance of the chi square value of 1.30 was 0.73. Null hypothesis six was RETAINED. Any change that occurs in learning style

does not seem to be related to course content.

Hypothesis Decision Summary

What follows is a summary of the general research questions, the related statistical hypotheses and the decision made relative to retention or rejection of each null hypothesis.

QUESTION 1 Is achievement in beginning computer programming classes different as a function of student learning style?

NULL HYPOTHESIS: 1. There is no difference between the mean achievement in beginning computer programming classes when compared to the first week learning style categories (PRELS) as measured by the Gregorc instrument.

DECISION: RETAINED

NULL HYPOTHESIS: 2. There is no difference in the mean achievement in beginning computer programming classes when compared to the last week of instruction learning style categories (POSTLS) as measured by the Gregorc instrument.

DECISION: RETAINED

QUESTION 2 Is achievement in beginning computer programming classes different as a function of student learning style and course content?

NULL HYPOTHESIS: 3. There is no difference between the mean achievement in beginning computer programming classes relative to course content and learning style

category as measured by the Gregorc instrument given during the last week of instruction.

DECISION: REJECTED, but adds no support to differences in achievement being a function of learning style.

QUESTION 3 Is there a factor or combination of factors selected from learning style, age, sex, high school performance, computer science education, formal computer programming experience, non-programming computer experience, computer programming ability, access to computers, languages able to program in, years of high school mathematics, college GPA, number of college mathematics courses, college class, and academic major which predicts achievement in beginning computer programming classes?

NULL HYPOTHESIS: 4. There is no linear relationship between achievement in beginning computer programming classes and the set of independent variables of learning style, age, sex, high school performance, computer science education, formal computer programming experience, non-programming computer experience, computer programming ability, languages able to program in, access to computers, years of high school mathematics, college GPA, number of college mathematics courses, college class, and academic major.

DECISION: REJECTED

QUESTION 4 Is beginning learning style affected by experiencing beginning computer programming instruction?

NULL HYPOTHESIS: 5. First week learning style preference is independent of last week learning style preference.

DECISION: REJECTED; last week preference is dependent upon first week preference; but where change occurs, there is a tendency towards the random and abstract preferences.

QUESTION 5 Does the content emphasis of beginning computer programming classes affect learning style?

NULL HYPOTHESIS: 6. The frequency of change versus no change in final week learning style categories is independent of course content.

DECISION: RETAINED

QUESTION 6 Is achievement in beginning computer programming classes different as a function of student learning style change between the beginning of instruction and the end of instruction?

NULL HYPOTHESIS: 7. There is no difference in achievement as a function of change in learning style from first week to last week in beginning computer programming classes.

DECISION: RETAINED

Summary

Chapter 4 contained the tests of hypotheses. Null hypotheses one, two, six and seven were retained, while hypotheses three, four and five were rejected. It was also

pointed out that when a learning style change occurred, the change tended to be toward the random and abstract ends of Gregorc's continua.

Chapter 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The general area of concern of this study was: Is there a relationship between learning style and achievement in beginning computer programming classes?

In order to look at this concern in greater depth, data were collected and analyzed as part of this study:

1. to determine if achievement in beginning computer programming classes is a function of learning style as well as other selected factors;
2. to determine if student learning style changes or is modified after experiencing beginning programming instruction and, if such changes exist, whether they are related to achievement.

The general direction provided by these two areas of concern led the investigator to ask six questions which guided the research. Those questions addressing part 1 of the problem statement were:

1. Is achievement in beginning computer programming classes different as a function of student learning style?
2. Is achievement in beginning computer programming classes different as a function of student learning style and course content?

3. Is there a factor or combination of factors selected from learning style, age, sex, high school performance, computer science education, formal programming experience, non-programming experience; computer programming ability, languages able to program in, access to computers, years of high school mathematics, college GPA, number of college mathematics courses, college class level, and academic major which predicts achievement in beginning computer programming classes?

The questions concerned with part 2 of the problem statement were:

4. Is learning style affected by experiencing beginning programming instruction?

5. Does the content emphasis of beginning computer programming classes affect learning style?

6. Is achievement in beginning computer programming classes different as a function of student learning style change between the beginning of instruction and the end of instruction?

The students involved in the research to answer the above questions were those found in all sections of Computer Science 101, Introduction to Scientific Computing; Computer Science 111, Introduction to General Computing; and Elementary Education 451, Computers in Elementary Education, classes offered at Montana State University in Bozeman, Montana during Winter Quarter 1984 that filled out the

instruments.

The data were collected using two instruments. One was the Gregorc Style Delineator (which formed a student learning style profile composed of scores for concrete sequential, concrete random, abstract sequential and abstract random learning styles.) Students could be classified as pointy-headed in one, two or three of the styles or have no preference at all with all scores within one to two points of each other. The other instrument was a questionnaire in which the participants were asked checklist and timeline type questions regarding various demographic factors, achievement history and selected course history.

Computer analysis of the data was performed using SPSS Version 9.1 on Montana State University's Honeywell Level 66 mainframe. The data analyses included both one-way and two-way analysis of variance, stepwise multiple regression and Chi Square Test of Independence.

The review of the literature clearly indicated a lack of research regarding achievement predictors relative to computer science courses and conflicting data relative to the relationship between learning style and achievement. This study added data to these areas.

Specifically, the results of this study led the investigator to conclude that, at least for students in the beginning computer programming classes investigated as a part of this study at Montana State University during Winter

Quarter 1984:

1. Achievement in beginning computer programming classes was not a function of learning style.

The factors of good high school performance, high college grade point average, junior, senior, or graduate status, high self-perception of one's computer programming ability, more years of high school mathematics experienced and being a female were predictors that accounted for the most letter grade variance in the prediction equation derived from the multiple regression analysis.

2. Last week learning style was significantly dependent on first week learning style. Where a change in learning style occurred, the change seemed to be towards the random and abstract ends of Gregorc's continua. There was no systematic or significant relationship to course content or achievement.

Conclusions and Additional Questions

The following conclusions are based upon the statistical analysis reported in Chapter Four:

1. Achievement in beginning computer programming classes is not significantly different as a function of student learning style in those Montana State University classes included in the investigation. Student learning style does not seem to affect a person's achievement in these classes.

2. Achievement in beginning computer programming classes is significantly different as a function of course content. Since course content directly impacts upon the instructors of the courses involved in the study, and due to instructor sensitivity to "outside" investigation of the classroom, this area was not investigated further.

3. Achievement in beginning computer programming classes is not significantly different when student learning style change between the first week of instruction and the final week of instruction is assessed. However, there appears to be a weak trend towards a learning style change favoring the random and abstract preferences. Does this mean that computer programming is not as sequential a process as the experts such as Rubenzer (1982) seem to indicate?

4. Learning style does not appear to be significantly affected by the content emphasis of beginning computer programming classes or by experiencing such classes. Further inspection of the results revealed that approximately 50% of the students did change learning style, but the change was not statistically significant. Where changes did occur, the trend was towards the random and abstract ends of Gregorc's continua. Does this mean that neither course content nor instructors have a bearing on learning style or learning style change? What accounts for the changes in learning style that did occur?

5. The factors of good high school performance, high college grade point average, junior, senior, or graduate status, high self-perception of one's computer programming ability, more years of high school mathematics experienced and being a female are predictors that account for the most letter grade variance in the prediction formula. Factors such as having Cobol, Basic and Pascal programming capability seemed to be negative factors in the prediction formula along with non-programming experience. Does this mean that programming experience gained in high school has a slightly negative impact on achievement in beginning programming classes at the college level? Does this mean that the current trend towards increased non-programming computer exposure at the elementary and high school levels also has a negative impact upon achievement in college level beginning computer programming classes?

It must be reemphasized at this point, however, that the prediction formula obtained through the stepwise multiple regression procedure only accounted for 30% of the letter grade variance found. Because of the small amount of variance accounted for, the usefulness of this formula would have to be seriously questioned. Some other variable or variables may exist that were not assessed as a part of this investigation. What variable or variables may need to be added?

Summary of Conclusions

To summarize these conclusions, there appeared to be no relationship between student learning style as measured by the Gregorc Style Delineator and achievement in beginning programming instruction. In addition, learning style did not significantly change after experiencing beginning computer programming instruction nor was there a relationship between learning style and course content. Where changes in learning style did occur, the tendency seemed to be toward the random and abstract ends of Gregorc's continua. Any causal interpretations are beyond the scope of this investigation's design and statistical analyses.

Finally, there do seem to be factors that are useful to a small degree in predicting letter grade achievement in beginning computer programming classes. However, the prediction equation derived after all variables were placed into the regression, still only accounted for 30% of the letter grade variance. This seems to be too low to be of much value in counseling and advising students relative to their chances of success in the areas of computer science and instructional computer programming.

Recommendations For Education

Because this study was of an exploratory nature, the design does not lend itself to making generalizations

relative to education. However, the results of this study did indicate that learning style, at least for approximately 50% of the students, does seem to change over a period of approximately eight weeks, but not significantly. Learning style does not seem to be as important a factor for students in institutions of higher education as it is in the elementary and secondary schools. This leads to the recommendation that greater attention be given to the concept of learning style at the elementary and secondary levels of our education system. In addition, further study of the older student seems appropriate to find out if the college and university student has learned to style-flex in order to be successful.

Recommendations for Research

Numerous questions have been raised earlier in this chapter relative to the conclusions based on the statistical analyses. These questions provide the basis for the following recommendations:

1. This study should be replicated at other institutions of higher learning to see if similar results are obtained.
2. Further research needs to be conducted to determine what differences in learning style change, modification or flexing may occur when comparing college and university students to elementary and secondary students.

3. Further research needs to be conducted using additional variables that could account for more of the achievement variance in beginning computer programming classes. What variables might have been left out of this investigation that could account for more of the variance?

4. Further research needs to be conducted to determine if controlling for the teacher's teaching style and learning style has an impact on achievement in beginning computer programming classes.

5. Additional research needs to be conducted to determine if computer programming classes are as "sequentially-based" as people assume and if the Gregorc instrument's sequential axis is measuring the same "sequential" process indicated by computer science educators as necessary in computer programming.

6. Some future research studies need to have a cause-and-effect design component to get at the issue of what causes learning style to change after exposure to beginning programming instruction.

7. Additional research looking at the effects of non-programming computer experience and types of high school computer programming experience on achievement in college level computer programming courses needs to be done.

8. The students in this study were unaware of their learning style. Would a knowledge of their learning style preference have an effect on their achievement? Further

research needs to be conducted in this area.

The questions presented in this Chapter provide a basis for future research designed to get at some of the issues raised.

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APPENDICES

APPENDIX A
QUESTIONNAIRE

SUPPLEMENTAL DATA QUESTIONNAIRE

STUDENT ID NUMBER _____ NAME _____

The name and student identification information requested on this instrument will only be used to correlate end-of-course data with the data from this instrument. After data analysis is completed, reference to name and ID number will be destroyed. Names and ID numbers will NOT be included in any reporting of the research. Confidentiality of the information is assured. By completing this instrument, you are agreeing to participate in this study. COMPLETING OR NOT COMPLETING THIS INSTRUMENT HAS NO EFFECT ON YOUR GRADE IN THIS COURSE!

ANSWER THE FOLLOWING STATEMENTS BY CHECKING THE APPROPRIATE RESPONSE TO EACH STATEMENT:

1. What is your age group?

___ 19 OR LESS
 ___ 20 TO 24
 ___ 25 TO 29
 ___ 30 TO 34
 ___ 35 or older

2. What is your sex?

___ MALE
 ___ FEMALE

3. Do you have regular access to a computer?

___ YES
 ___ NO

4. What is your college GPA?

___ 3.50 - 4.00
 ___ 3.00 - 3.49
 ___ 2.50 - 2.99
 ___ 2.00 - 2.49
 ___ BELOW 2.00

5. What languages can you program in? (Check all that apply.)

___ BASIC
 ___ PASCAL
 ___ MACHINE LANGUAGE
 ___ OTHER (LIST): _____

6. What is your college class?

___ FRESHMAN
 ___ SOPHOMORE
 ___ JUNIOR
 ___ SENIOR
 ___ GRADUATE
 ___ OTHER (LIST): _____

ANSWER THE FOLLOWING STATEMENTS BY PLACING AN "X" IN THE APPROPRIATE PLACE ON EACH LINE THAT BEST ANSWERS THE QUESTION:

7. How would you rate your overall high school academic performance?

_____ "C" AVERAGE "B" AVERAGE "A" AVERAGE

8. How many YEARS of HIGH SCHOOL MATHEMATICS have you had?

0 1 2 3 4 5 OR MORE

9. How many (what number of) COLLEGE MATHEMATICS COURSES have you had?

0 1 2 3 4 5 OR MORE

10. How many YEARS of computer science education have you had including high school?

0 1 2 3 4 5 OR MORE

11. How many YEARS of NON-PROGRAMMING computer experience have you had including high school?

0 1 2 3 4 5 OR MORE

12. How many YEARS of PROGRAMMING experience have you had including high school?

0 1 2 3 4 5 OR MORE

13. How would you rate your computer programming ability at the beginning of this course?

NONE POOR MODERATE GOOD OUTSTANDING

APPENDIX B

PERMISSION FORMS



Montana State University
Bozeman, Montana 59717

Department of Secondary Education and Foundations
College of Education

Telephone (406) 994-4752

I hereby grant Roderick M. Thronson, doctoral candidate in the Department of Secondary Education and Foundations, permission to administer the *Gregorc Style Delineator* to my class, CS 101 4, III Section 2, during the first week of Winter or Spring Quarter, 1984 and during the last week of instruction in the quarter. It is understood that the administration of the instrument will consume approximately ten minutes of my instructional time.

I will also allow the researcher access to the final average and final letter grade for each student participating in the research.

ELIZABETH COFFEY
PRINTED NAME

Elizabeth Coffey 11/2/83
INSTRUCTOR'S SIGNATURE DATE

Mark Amund 1/27/84
INSTRUCTOR'S SIGNATURE DATE

Nancy Kuenen 1/30/84
INSTRUCTOR'S SIGNATURE DATE



Montana State University
Bozeman, Montana 59717

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I will also allow the researcher access to the final average and final letter grade for each student participating in the research.

Dr. Jane Stone
PRINTED NAME

Dr. Jane Stone 11/7/93
INSTRUCTOR'S SIGNATURE DATE



Montana State University
Bozeman, Montana 59717

Department of Secondary Education and Foundations
College of Education

Telephone (406) 994-4752

I hereby grant Roderick M. Thronson, doctoral candidate in the Department of Secondary Education and Foundations, permission to administer the *Gregorc Style Delineator* to my class, ~~ESPEL 451~~, Section 01 during the first week of Winter or Spring Quarter, 1984 and during the last week of instruction in the quarter. It is understood that the administration of the instrument will consume approximately ten minutes of my instructional time.

I will also allow the researcher access to the final average and final letter grade for each student participating in the research.

L. W. ELLERBRUCH
PRINTED NAME

L. W. Ellerbruch 11/15/83
INSTRUCTOR'S SIGNATURE DATE

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