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EFFECTS OF LEARNING STYLE AND LEARNING ENVIRONMENT ON ACHIEVEMENT BY LEVELS OF LEARNING

The University of Oklahoma PH.D. 1983

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EFFECTS OF LEARNING STYLE AND LEARNING ENVIRONMENT ON ACHIEVEMENT BY LEVELS OF LEARNING

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

BY

RAE JEAN MCCALL

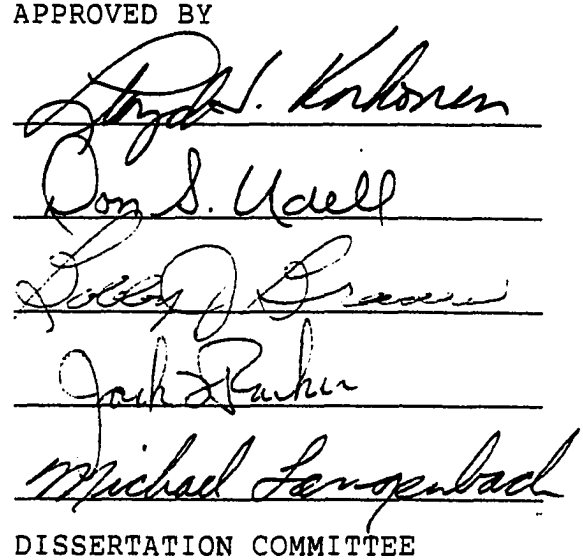
Norman, Oklahoma

1983

EFFECTS OF LEARNING STYLE AND LEARNING ENVIRONMENT

ON ACHIEVEMENT BY LEVELS OF LEARNING

APPROVED BY



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ABSTRACT

EFFECTS OF LEARNING STYLE AND LEARNING ENVIRONMENT ON ACHIEVEMENT BY LEVELS OF LEARNING

By: Rae Jean McCall

Major Professor: Lloyd J. Korhonen, Ph.D.

This study was designed to determine whether or not interactions occur between/among individual differences of learners with instructional treatments. Based on the theory of experiential learning, David A. Kolb's conception of learning styles was used to identify individual differences in learners. The investigator sought to determine if individuals in different learning style categories would achieve more in certain learning environments, and if this matching would affect their ability to learn at different levels. It was expected that there would be interaction between learning style and learning environment on achievement. It was also anticipated that there would be interaction between learning style and levels of learning. Finally, it was predicted that there would be a difference between learning environments and levels of learning.

Ten classes of adults enrolled in formal non-credit programs of basic computer programming were involved in the study. Based upon interviews with the instructors and

observation of the classes, five of the classes were identified as conforming environments and five were identified as independent environments. Students agreeing to participate in the study completed a Learning Style Inventory, a pretest, and a biographical questionnaire during the first class session. Upon completion of the sixth class session, the students were administered a posttest consisting of fifteen questions identified in the rote level of learning category and fifteen questions in the understanding level of learning category.

The pretest and posttest instruments were computer scored and analyzed. A packaged computer system, Statistical Analysis System (SAS), was used to summarize scores and responses for each subject. Since the total number of observations produced unequal cell sizes, a table of random numbers was used to eliminate observations in each category that exceeded fifteen. A total of 120 subjects was used in the statistical analysis.

An analysis of covariance (ANCOVA) revealed that learning style and learning environment do interact to affect achievement. However, a multiple analysis of covariance demonstrated that there were no differences between learning style and levels of learning.

It was also found that there was no difference between rote questions and understanding questions for each of the learning environments in a paired comparison t-test.

EFFECTS OF LEARNING STYLE AND LEARNING ENVIRONMENT ON ACHIEVEMENT BY LEVELS OF LEARNING

CHAPTER I

Introduction

In the relatively short time since its inception, the microcomputer has been able to touch all aspects of human life. It is no longer a question of whether or not the microcomputer will be used, but rather a question of when and to what extent it will be used. Predictions are often stated that the microcomputer will become as commonplace in the home as the telephone and television are currently (Rockart and Scott Morton, 1975).

For adult educators, the challenges provided by this medium are enormous. Not only are the opportunities apparent for training the current adult population, but the future adult population may be well acquainted with learning projects on the microcomputer. Relatively few research studies are available to provide us with information on how adults, with varied learning styles, can best learn basic computer programming for the microcomputer.

The delivery system of non-credit adult education programming provides an opportunity for adults of all ages, educational backgrounds, and occupations to learn a variety

of subjects. However, the available adult education programs on basic computer programming for the microcomputer demonstrate that many methods are employed at varying degrees to train persons in this area.

It is generally agreed that all students do not learn in the same ways. While several approaches attempt to establish research on individual differences, no single theory has found widespread acceptance (Danielson and Seiler, 1979). Two concepts, however, have been developed to foster an understanding of how people process information: cognitive style and learning style. The concept of "learning style" appears more recently in research, but includes many of the insights from the earlier research in cognitive style.

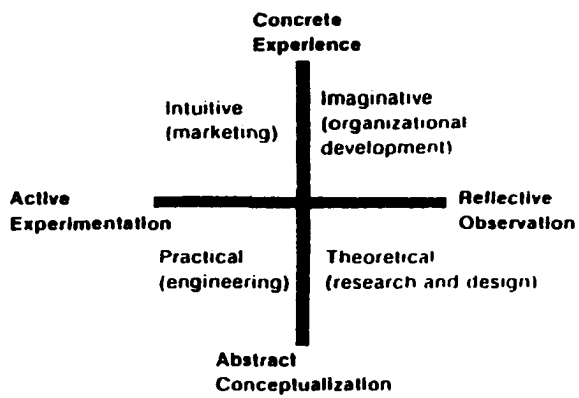
Although several instruments have been developed to measure learning style, they each have much in common. By comparing the work of researchers in fields ranging from psychology to management training, McCarthy (1980) found that learning style research presented almost perfectly parallel learning schemes. She developed her comparison based on David Kolb's research because it "represented a breakthrough . . (in) . .formulating learning style findings into model form," (McCarthy, 1980, p. 26).

This approach is represented in the following comparison of learning style research based on the model developed by Kolb.

FIGURE 1

McCarthy's Comparison of Learning Style Research

KOLB



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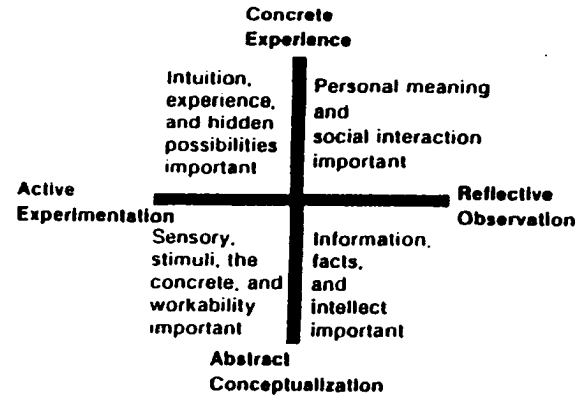

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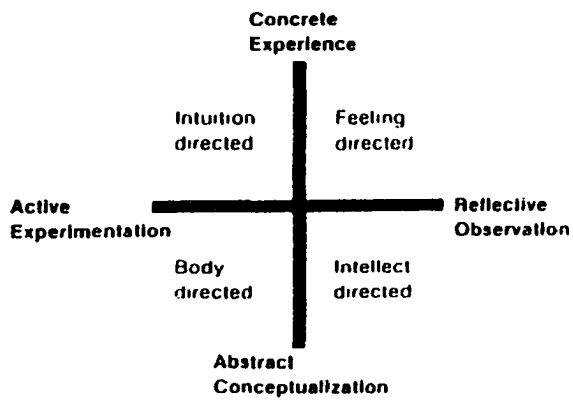

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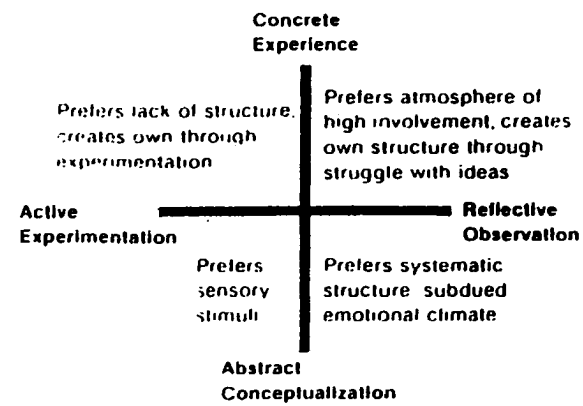


(McCarthy, 1980, p. 34)

David A. Kolb (1974) identifies four styles of learning based on the theory of experiential learning: accommodators, assimilators, divergers, and convergers. He states that adults will have a predominance in one of these four styles, although other styles can be developed.

To identify the learning styles, Kolb provides a model based on experiential learning theory, which is founded on the Jungian (Jung, 1923) concept of styles or types. The experiential model emphasizes the important role that experience plays in the learning process, an emphasis that differentiates this approach from other cognitive theories of the learning process (Kolb, 1976).

In this model, learning is conceived as a four state cycle:

> The learner, if he is to be effective, needs four different kinds of abilities: Concrete Experience abilities (CE), Reflective Observation abilities (RO), Abstract Conceptualization abilities (AC), and Active Experimentation (AE) abilities. That is, he must be able to involve himself fully, openly, and without bias in new experiences from many perspectives (RO); to create concepts that integrate his observations into logical sound theories (AC); and to use these theories to make decisions and solve problems (AE). (Kolb, 1976, p. 3)

Examination of the four stage learning model suggests that learning requires abilities that are polar opposites and that the learner must choose which set of learning abilities he will bring to bear in a specific learning situation. Therefore, learning styles are developed

through trying to resolve conflicts in family, school, or job. These conflicts do not have to be major or critical, as long as they involve decisions regarding which of the polar extremes of their learning abilities to use (Kolb, 1976).

The four learning styles, their respective predominant learning abilities, and characteristics are:

(1) Converger: Abstract Conceptualization and Active Experimentation. Convergers can focus on specific problems through hypothetical-deductive reasoning. They seem to do best where there is just one right answer or just one solution to a problem. Convergers have been characterized as rather unemotional, and seem to prefer to deal with things rather than people.

(2) Diverger: Concrete Experience and Reflective Observation. The exact opposite of Convergers, these people look at everything from many perspectives and organize them into a meaningful "gestalt." They are imaginative and artistically inclined. They tend to be emotional and like working with ideas in areas such as the humanities and liberal arts.

(3) Assimilator: Abstract Conceptualization and Reflective Observation. Assimilators are very good at inductive reasoning, and in bringing together different observations into an integrated explanation. Assimilators are best at taking in data and devising theoretical models,

although they are not concerned with the practical use of these models.

(4) Accommodator. Concrete Experience and Active Experimentation. Accommodators tend to rely on other people for information to a great extent, rather than their own analytic ability. They take more risks than the other three learning styles as they capitalize on their greatest asset: carrying out plans, getting involved in new experiences, and solving problems on a trial-and-error basis (Kolb, 1976).

Kolb's application of these concepts was primarily in the areas of occupational socialization, career development, and management education; therefore, it is important that implications for learning styles as a determinant of achievement be tested in different methods of teaching. The theory of experiential learning is especially useful in understanding how students differ from one another and why. However, the true challenge of instruction is to provide the types of learning activities that allow each student to learn successfully. Since courses of basic computer programming include individuals with varied learning styles, an understanding of curriculum in terms of specific activities and environmental orientations that address learning skills of individual students would be advantageous.

Researchers interested in learning style have tried to obtain specific indicators of how a person (or a group) learns in order that a prescriptive approach may be taken in specific learning contexts (Kirby, 1979). For example, there is evidence that field-dependent students (Kolb's Divergers and Accommodators) are more easily reinforced by external evaluation (grades, praise, criticism), whereas field independents (Kolb's Convergers and Assimilators) are less influenced by the rewards of their social surroundings (Witkin, 1973). There is also some evidence that field independents are able to deal with larger modules and with less frequent feedback than field dependents (Renzi, 1974; Schwen, 1970 in Cross, 1976).

One particularly notable conclusion derived from learning style research is that students and instructors whose learning styles are matched tend to judge each other more positively than those who are unmatched (Cross, 1976, Kirby, 1979). It has been argued, however, that a steady diet of matching the student learning style with the learning environment he or she most prefers may not be in the best long-term interest of the student since it does not allow the opportunity for developing skills in the other styles (Chickering, In Messick and Associates, 1976).

Three studies provide a general background for the present investigation into learning styles. Robinson and Gray (1974) reported that a relationship exists between a

learner's style and certain school learning variables; that is, certain learner styles function best with certain methods of instruction. The second study reaches a somewhat different conclusion. Coop and Brown (1970) compared the effects of cognitive style and method of teaching on two categories of learning achievement and found that while teacher structured lecture was superior to self study, there was no relationship between method of teaching and cognitive style or between cognitive style and achievement. The third study conducted by Danielson and Seiler (1979) produced a significant relationship between cognitive style and achievement. They also found that subjects receiving a printed media treatment scored higher on rote level questions and subjects receiving a television treatment scored higher on understanding level questions. Although these studies reached slightly different conclusions, they contain similiarities in the use of learning styles as a means of investigating both the teaching process and achievement.

The theoretical basis for the present study is the Lewinian formula--$B = f(P,E)$, or Behavior is a function of the Person and the Environment (Hunt and Sullivan, 1974).

> B-P-E analysis requires first identifying each of the three components--Behavior, Person, and Environment--in the specific situation. A B-P-E analysis of a psychological experiment would specify the Behavior (or dependent variable), viewing it as jointly determined by the Person (kind of subjects) and the Environment (treatments or independent variables). (Hunt, 1975, p. 217)

The B-P-E formula requires that problems be stated and conclusions be drawn in a differential form. Because there is a strong tendency to look for the one best approach in education, a differential approach will overcome simplication of the problem. Crombach and Snow describe this aim as:

> . . to establish a spirit (or better, a "grammar") within which educational researchers and planners think routinely of learner variables when designing or selecting instructional treatments, and of manipulative treatment conditions when defining school-relevant individual difference variables. (Cronbach and Snow, in Hunt, 1975, p. 218)

The present study includes each component of the Lewinian formula as variables: (1) achievement is identified as "Behavior," (2) learning style is the "Person," and (3) learning environment is the environment. Therefore, the adjusted formula would read:

Achievement = f (Learning style, Learning environment).

It appears that there is very little known about the learning traits and needs of learners who select non-credit adult education programs. There also does not appear to be any evidence on the effect that learning style has on the student's ability to learn material at different levels of complexity. For program planners in adult education, these important issues are of major concern.

Statement of the Problem

How do learning environment and learning style interact to affect achievement by levels of learning in basic computer programming courses? More specifically, the following research questions will be explored:

(1) If individuals who prefer the Reflective Observation mode of learning are classified as assimilators and divergers and those who prefer the Active Experimentation mode of learning are classified as convergers and accommodators, then will assimilators and divergers achieve more than accommodators and convergers on a comprehensive examination in a conforming environment and those identified as accommodators and convergers achieve more than assimilators and divergers in an independent environment?

(2) If individuals who prefer the Abstract Conceptualization mode of learning are classified as convergers and assimilators and those who prefer the Concrete Experience mode of learning are classified as divergers and accommodators, then will convergers and assimilators achieve more on the rote level of learning questions than accommodators and divergers and will accommodators and divergers achieve more on the understanding level of learning questions than assimilators and convergers?

(3) Is there a difference between learning environments (conforming and independent) and levels of learning (rote and understanding)?

Hypotheses

(1) There will be significant interaction effects between learning style and learning environment on combined rote and understanding achievement scores.

(1.1) Assimilators and divergers will achieve more than accommodators and convergers in a conforming environment.

(1.2) Accommodators and convergers will achieve more than assimilators and divergers in an independent environment.

(2) There will be significant interaction effects between learning style at the rote and understanding levels of learning.

(2.1) Accommodators and divergers will score higher than assimilators and convergers on the rote level of learning questions.

(2.2) Assimilators and convergers will score higher than accommodators and divergers on the understanding level of learning questions.

(3) There will be a difference between learning environments at the rote and understanding levels of learning.

(3.1) Students in the independent environment will attain more at the understanding level of learning.

(3.2) Students in the conforming environment will attain more at the rote level of learning.

Assumptions

It is assumed that all subjects gave accurate information on each of the instruments used. It is also assumed that pre- and post-test procedures provide an accurate accounting of the individual's ability.

Limitations

This study is limited to the population defined. Although it could be assumed that other courses and other types of institutions would produce similar results, the population of adult education students enrolled in non-credit basic computer programming courses is the only generalizable population.

It should also be noted that this study deals with established classes in Basic Computer Programming. Although the course content was consistent for the purpose of research, the actual content may have included additional competency areas. This prevented the researcher from obtaining a measure of learning rate, which would have provided additional insight into the issues at hand.

Definition of Terms

Learning style. The individual's characteristic means of perceiving and processing information (Kolb, 1976). Learning style is similar to cognitive style in most regards, but the context is more specific--"the student's consistent way of responding and using stimuli in the context of learning" (Claxton and Ralston, 1978, in Kirby, p. 8).

Cognitive style. "Characteristic ways of using the mind," (Cross, 1976, p. 112), or "a person's typical modes of perceiving, remembering, thinking, and problem solving" (Messick, in Kirby, p. 7).

Learning environment. "A stimulus, aside from instruction, that predicts learning" (Walberg, 1974, p. 82). For the purpose of this study, conforming and independent environments will be considered.

Conforming environment. Classes categorized by the criteria developed by Domino (1968). Basically, ". . . course material. . . presented solely through lectures, great emphasis. . . placed upon factual knowledge, classroom attendance. . . required, and course content closely paralleled textbook assignments (Domino, 1971, p. 428).

Independent environment. Classes categorized as independent ". . . (where) emphasis (is) placed upon ideas rather than facts and upon the active participation of students in the learning process" (Domino, 1971, p. 428).

Achievement. Operationally defined for this study as the score attained on an achievement test designed by the researcher in conjunction with the instructors. The achievement score is a combination of the score for rote level of learning questions and the score for understanding level of learning questions.

Rote Level of Learning. The rote level of learning is the lowest level. Bloom (1956) describes this as ". . . those behaviors and test situations which emphasize the remembering, either by recognition or recall, of ideas, materials, or phenomena" (Bloom, 1956, p. 62). For the purposes of this study, fifteen questions on the comprehensive examination are identified as rote level of learning questions.

Understanding Level of Learning. This classification includes ". . . those objectives, behaviors, or responses which represent an understanding of the literal message contained in a communication" (Bloom, 1956, p. 89). In this study, fifteen questions on the comprehensive examination are identified as understanding level of learning questions.

CHAPTER II

Review of Related Literature

Although the past three decades have seen a vast amount of research on cognitive styles, the application of these concepts to problems in education is just in its beginning phase. Kogan (1971, p. 243) observes that until recently there was an

> almost total lack of articulation. . . between the psychological study of cognition, on the one hand, and educational research and practice, on the other. Cognition, after all, refers to the process by which knowledge is acquired: perception, memory, thinking, and imagery--and one might have anticipated a long-term and fruitful association between psychological research and the world of education.

There is now some evidence to indicate that the gap is being bridged between research and practice. For example, cognitive style has been found to be an important variable in the preferences students express and in the choices they actually make in academic situations when options are available to them (Witkin, in Messick and Associates, 1976). In addition, some evidence is available on the consequences of match or mismatch in cognitive style between teacher and students (Cross, 1976, Kirby, 1979).

Although the efforts in cognitive style research have produced important results for the educational setting, recent investigations focussing on the concept of "learning

style" seem to hold great promise in identifying strategies for combining course materials and presentations to the individual needs of the student (Kirby, 1979). As stated by Peterson (In Mitzel, 1980, p. 845):

> Recently, many educators have argued that learning can be improved by adapting teaching to a student's learning style or by putting teachers with students who have similar learning styles. Unfortunately, these recommendations are based upon theory rather than upon research.

Theories of Cognitive and Learning Style

One of the first investigators into the differences in the way people process and perceive information was Carl Jung (1921). He defined four categories: Feelers, Thinkers, Sensors, and Intuitors. This conceptualization closely parallels the more recent investigations of Fischer and Fischer (1979), Kolb (1976), Gregorc (1979), and McCarthy (1979). By comparing the findings of these researchers, McCarthy (1980, p. 26) observed:

> In fields ranging from psychology to management training, researchers have made nearly the same discoveries. Though they worked separately, with different techniques, in different areas, they came up with almost perfectly parallel learning schemes.

In order to explore the research of learning style investigators, it is useful to describe some of the instruments designed to measure learning style and their implications.

The Canfield and Lafferty Learning Style Inventory (1976) is designed for adults; measuring preferences for such items as (a) academic conditions, (b) structural conditions, (c) content, and (d) expectation of performance level. By implementing the Learning Style Inventory, Shuntich and Kirkhorn (1979) found that the instrument could serve as a guide in implementing learning activities (as well as evaluation) for a whole class as well as individual students.

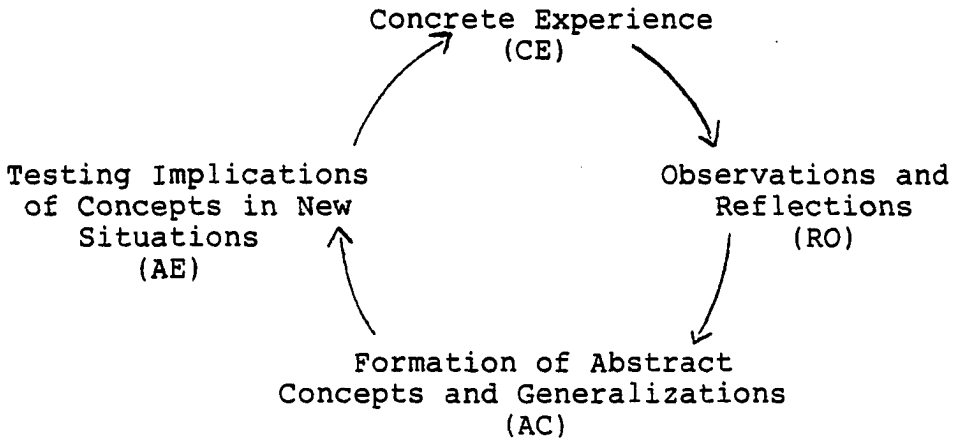
Based on studies of children up through grade 12, Dunn and Dunn's (1978) research using their Learning Style Inventory provides insight into the self-concept of the students in a learning environment:

> In general, a dimension related to being unsettled, perhaps not wanting to be alone, and learning through the auditory senses seemed to characterize individuals who had a low self-concept;" whereas "Individuals who had a high self-concept were persistent, able to stay in one place, and liked to learn in several ways." (Price, Dunn, and Dunn, in Kirby, 1979, p. 73)

An instrument designed by Kolb (1976) is based on the theory of "experiential learning," tying it to its origins in the social psychology of Kurt Lewin in the 1940's. "The core of the model is a simple description of the learning cycle and how experience is translated into concepts which in turn are used as guides in the choice of new experiences." (Kolb, 1976, p. 2)

Figure 2

The Experiential Learning Model



(Kolb, 1976, p. 2)

From this model, Kolb postulates that learning requires abilities that are polar opposites. More specifically,

> . . .there are two primary dimensions to the learning process. The first dimension represents the concrete experiencing of events at one end and abstract conceptualization at the other. The other dimension has active experimentation at one extreme and reflective observation at the other. Thus, in the process of learning, one moves in varying degrees from actor to observer, from specific involvement to general analytic detachment. (Kolb, 1976, p. 3)

Over time, the constant use of these dimensions in a characteristic fashion can be termed our "learning style." Kolb identifies four styles: the Converger, the Diverger, the Accommodator, and the Assimilator.

There is some evidence that learning styles are close correlates of occupational preferences (Kolb, 1976). The

theory of experiential learning provides a framework for conceptualizing how individual learning styles have a much broader meaning. That is, they are not limited to the educational sense, they also involve the individual's adaptation to life, such as decision-making, problem-solving, and lifestyle in general (Kolb, 1976).

One interesting adaptation of the Kolb model was investigated by McCarthy (1979). By combining the learning style approach with relevant findings in neuropsychology, McCarthy designed a system to guide high school students into one of four "schools within a school," based on curriculum and instructional methods. She found that those students who followed the indications of the survey did significantly better than those who did not (McCarthy, 1979). The results and a further developed model for teaching are contained in her book, The 4Mat System: Teaching to Learning Styles With Right/Left Mode Techniques (McCarthy, 1981).

Previous Attempts to Link Student Learning Styles with Classroom Factors

The history of research on individual differences in students is a long one that has provided many practical insights into the learning process. Perhaps the most significant contributions in research have related to "learning ability" through the use of intelligence testing (Gagne,

p. xi). However, the investigations into cognitive or learning style and their relationship to the learning process are relatively recent.

Reviews of recent research by Cronbach and Snow (1977) and Witkin et al. (1977) indicate that attempts to match teachers to students based on learning styles have yielded inconsistent results. Kleine states: "methodologically, a need continues to exist for the qualitive description and analysis of classroom phenomena as well as the quantitative analysis seeking relationships among these phenomena" (1982, p. 13).

One study conducted by Domino (1968) utilized the California Psychological Inventory (CPI) to assess achievement motivation of college juniors. He hypothesized that conforming and independent achievement motivation is related to scholastic achievement in a setting rewarding conforming behavior and in a setting rewarding independent behavior. The sample included four groups of 22 subjects each chosen from the extreme corners of the Achievement through Conformity (Ac) and Achievement through Independence (Ai) distribution. Findings revealed a significant interaction between teaching method and student achievement orientation.

A second study by Domino (1971) again used extreme groups to test the hypothesis that there is an interaction between a student's achievement orientation and the

teaching style to which he is exposed. This interaction, he stated, "differentially affects both the amount of learning that takes place and the degree of expressed satisfaction with the scholastic environment" (Domino, 1971, p. 427). Findings indicate that students taught in a manner consistent with their achievement orientation obtained significantly higher scores and evaluated their experience more positively than their peers taught in a dissonant manner.

Closely related to the concept of cognitive style "matching" is Hunt's Conceptual Level Matching Model. He contends that an important ingredient in the learning process is the degree of structure, or the "degree of organization provided by the learning environment" (Hunt, 1975, p. 219). The style component of Hunt's research is Conceptual Level which he describes as:

> Conceptual Level is a person characteristic, indexing both cognitive complexity differentiation, discrimination, and integration) as well as interpersonal maturity (increasing self-responsibility). A person at a higher conceptual level is more structurally complex, more capable of responsible actions, and most important, more capable of adapting to a changing environment than a person at a lower Conceptual Level. (Hunt, 1975, p. 217)

The basic matching principle proposed by Hunt is summarized as "low CL learners profiting more from high structure and high CL learners profiting more from low

structure, or in some cases, being less affected by the variation in structure" (Hunt, 1971, p. 44).

In studies designed to test the matching principle, low and high CL students were identified and assigned to several conditions of varying degrees of structure. Low CL students performed better with high structure than with low structure, whereas, an ordinal interaction (performing well in both conditions) was discovered for the high CL students (Hunt, 1975).

Another study that provides support of the concept of matching instructional methods with student learning styles was conducted by Robinson and Gray (1974). The research included 258 fifth grade children from 12 classrooms in five schools as the sample. Students were identified as one of three learning styles: categorical, descriptive, or relational. Various school learning variables such as reading comprehension, mathematical concepts, and language usage were tested for their relationship to learning style after variance attributed to verbal and nonverbal IQ was taken into consideration. The findings indicate that learning style was differentially related to school learning for both boys and girls (Robinson and Gray, 1974).

Somewhat different results were obtained in a study conducted by Coop and Brown (1970). A sample of eighty college subjects was used to determine the effect of cognitive style and teaching method on three different aspects

of subject matter achievement: (1) factual content, (2) conceptual-generalization content, and (3) total content. In contrast with previous studies, this investigation found that a teacher-structured-presentation method of instruction was "significantly superior to an independent-problem-solving method of instruction on all three dependent measures" (Coop and Brown, 1970, p. 400). They discovered no significant difference between learning styles on any of the dependent measures, nor was there a significant interaction between style and teaching method.

Only one study that identified the population of adults enrolled in non-credit courses was discovered by the researcher. In this study, a content learning package was prepared for presentation in two instructional media, print and television. Following instruction, the subjects were tested for achievement and levels of learning. The results indicated that subjects receiving the print treatment scored significantly higher on the rote level questions than they did on the understanding level questions. Subjects receiving the television treatment scored higher on the understanding level questions. It was also found that there was a difference between learning style and achievement at different levels of learning (Danielson and Seiler, 1979).

From the research cited, it is concluded that learning style and learning environment are important variables in the learning process. Additional research is warranted in identifying these characteristics and their relationship to levels of learning.

CHAPTER III

METHODOLOGY

Design of the Study

The research design employed in this study is quasi-experimental. The scientific problem is to determine if learning environment and learning style will interact to affect achievement by levels of learning in basic computer programming. An interaction is said to be present when "a situation has one effect on one kind of person and a different effect on another" (Cronbach and Snow, p. 3).

Population of the Study

Adults enrolled in formal non-credit programs of basic computer programming are identified as the population to be considered. Ten classes of students enrolled during the fall semester of 1983 in five Area Vo-Tech Centers in Oklahoma were included in the study. Since the total number of students produced unequal cell sizes, a table of random numbers was used to eliminate students in each cell that exceeded fifteen. Therefore, the total number of subjects included in the study is 120.

Variables

The comparison variables identified in this study are: (1) type of learning environment and (2) learning style. The dependent variables identified in the study are: (1) achievement and (2) level of learning. In addition, demographic variables of age, educational level, and sex will be recorded to test the normative aspect of the data and provide insight into individual characteristics of adult subjects.

Instrumentation

Learning Style Inventory

Adult learning style was determined for each subject by administering the Learning Style Inventory (LSI), a self-administered instrument developed by David A. Kolb. Reliability coefficients of approximately .80 have been established for the questionnaire by applying the Spearman-Brown prophecy formula for split-half reliability for five different groups of individuals (Kolb, 1976).

Validity for the Learning Style Inventory has also been established through correlations with the Myers-Brigg Type Indicator (Myers, 1962), the Thematic Apperception Test (TAT), and the FIRO-B (Schultz, 1958).

Reliability coefficients and validity estimates for the Learning Style Inventory were also calculated for adult

students included in the study and a pilot study consisting of six subjects.

Achievement

The achievement level of individual students was determined by a comprehensive examination given at the completion of the course. All instructors involved in the study agreed upon desired outcomes (minimum competencies) before the study began; therefore, minimum content was consistent for the ten groups. A pre-test composed of 20 questions was administered to each of the ten groups. If results of the pretest indicate that no difference exists between the groups, post-test results will be used to determine the achievement level of subjects. If a difference exists between the groups, an analysis of covariance will be used.

Levels of Learning

A multiple choice pre-and-post test was designed to include the two independent levels of learning: rote and understanding. To determine the validity of the achievement test, two procedures were used. The first determined the validity of the two levels of learning and the second determined the content validity of the instruments. In order to determine the validity of the levels of learning (rote and understanding), a group of Basic Computer Programming Instructors served as a panel of experts. Each

instructor was provided with a definition of the two levels of learning and a pool of 100 test questions. The panel was then instructed to read the descriptions of the two levels of learning and to classify each question into one of three categories: (1) rote, (2) understanding, or (3) neither rote or understanding. The decision to retain an item was based on agreement of at least 80% of the instructors as to the question's classification. Items which were classified as neither rote or understanding were dropped.

The content validity of the instrument was determined by the instructors. Each was asked to review the pool of 100 questions and to make two judgements about the items. First, can the item be answered from the material presented in the course? Second, is one of the alternatives the correct answer? Agreement among all instructors was required.

In addition, an item analysis and discrimination index procedure was employed to assure fairness among items.

Data Acquisition

The data collection process consisted of three stages: (1) Preliminary, (2) Beginning of class, and (3) End of class. During the first stage, instructors for each of the selected classes met with the researcher to agree upon the course content (minimum competencies) and review the pre-test and post-test measurements.

At the beginning of each selected class session, the researcher made introductory remarks and administered the Learning Style Inventory and course pre-test. Results of these two instruments and demographic information about the subject were recorded on coded master subject sheets to assure confidentiality.

At the end of the sixth class session, the post-test instrument was administered. All information was recorded on the subject master sheet.

Data obtained from the subjects was audited and coded for analysis. The Statistical Analysis System (SAS), a packaged computer program, was used to analyze this information.

Treatment of the Data

To test the first hypothesis, there will be no significant interaction effects between learning style and learning environment on achievement scores, a 4x2 analysis of covariance (ANCOVA) was performed.

In additon to the F value for the ANCOVA ($p. < .05$), an individual post-hoc test, Tukey's HSD, will be used to test main effects within cells which were most significant.

The remaining hypotheses were tested by the use of multivariate analysis of covariance (MANCOVA). The use of MANCOVA provides two levels of analysis and a priori decision should be made as to which is going to be used. The

two choices are: (1) a collective test of significance -- the global F or (2) the step down F. In this case, the step down F would be appropriate. The alpha level for all statistical tests is set at the .05 level.

CHAPTER IV

Analysis of Data

In the first stage of data analysis, pretest measures were scored and demographic data were coded. After each class had completed its sixth session, the post-test was administered. Computer-scoring methods were used for the pre-and post-test measurements to produce reliability estimates for each class (see Appendix E).

The second stage of data analysis consisted of merging the pre-and post-test measure with demographic responses by an identification code assigned to each subject. Utilizing the Statistical Analysis System (SAS), a packaged computer system, data were grouped by class and summarized for learning style, learning environment, and demographic information (see Appendix E).

The original data yielded 165 observations. Since the statistical techniques of ANCOVA (Analysis of Covariance) and MANCOVA (Multiple Analysis of Covariance) were to be used, cell sizes were examined (see Table 1). Since cell sizes were not equal, a table of random numbers was used to eliminate observations in each cell that exceeded fifteen. This process produced a total of 120 observations for the final analysis.

TABLE 1

Cell Sizes

	Accommodator	Diverger	Assimilator	Converger
Conforming	29	18	15	16
Independent	28	20	17	15

Tests of the Hypotheses

Three hypotheses were tested in this study, each arising from a research question. Each hypothesis will be presented, followed by the results of its test.

1. There will be significant interaction effects between learning style and learning environment on combined rote and understanding achievement scores.

(1.1) Assimilators and divergers will achieve more than accommodators and convergers in a conforming environment.

(1.2) Accommodators and convergers will achieve more than assimilators and divergers in an independent environment.

The hypothesis was tested by a 4 x 2 Analysis of Covariance (ANCOVA) with learning style and learning environment identified as classification variables and the combination of rote and understanding categories of the post-test covaried by the subject's pre-test score as the

dependent variable. Results of the ANCOVA given in Table 2 indicate significant interaction effects between learning style and learning environment ($F = 5.96$, $p > .0001$).

TABLE 2

Summary of Analysis of Covariance for Learning Style and Learning Environment

Source of Variation	df	Mean Square	F Value	p
Model	8	63.4408	5.96	.0001
Error	111	10.6526		
Corrected Total	119			

Further analysis revealed significant main effects for learning style ($F = 3.94$, $p > .0103$), learning environment ($F = 14.90$, $p > .002$), and the interaction of learning style and learning environment ($F = 6.86$, $p > .0003$). Means and standard deviations are reported in Table 3. A post-hoc comparison procedure, Tukey's HSD test, was conducted to examine the differences between group means. This produced a minimum significant difference of 2.19817 for learning style and 1.1808 for learning environment. It can then be concluded that learning style and learning environment do interact to affect achievement. Thus, the first hypothesis was supported.

TABLE 3

Means and Standard Deviations* of
Combined Post-test Measurements

	Learning Style			
	Accommodator	Diverger	Assimilator	Converger
Conforming Environment	17.53 (3.11)	19.20 (2.86)	18.27 (3.45)	18.33 (2.89)
Independent Environment	22.53 (2.10)	18.60 (3.94)	18.07 (4.15)	23.33 (3.06)

*Standard deviations in parentheses

2. There will be significant interaction effects between learning style at the rote and understanding levels of learning.

(2.1) Accommodators and divergers will score higher than assimilators and convergers on the rote level of learning questions.

(2.2) Assimilators and convergers will score higher than accommodators and divergers on the understanding level of learning questions.

This hypothesis was tested by a 4 x 2 MANCOVA (multiple analysis of covariance) with learning style identified as the classification variable and levels of learning (rote and understanding) covaried with pre-test scores as the dependent variables.

The MANCOVA procedure for learning style produced significance for the rote level of learning questions ($F = 2.80$, $p > .0294$). However, the understanding level of learning questions was not significant ($F = 2.20$, $p > .0729$). The means and standard deviations for the interaction hypothesis for the rote level appear in Table 4. Table 5 contains the means and standard deviations for the understanding level questions. Table 6 contains the combined means for learning styles.

TABLE 4

Mean Scores and Standard Deviations for Rote Questions

	n	$\bar{X}$	SD
Conforming Environment			
Accommodator	15	8.933	1.980
Diverger	15	9.600	1.765
Assimilator	15	9.067	1.668
Converger	15	9.600	1.920
Independent Environment			
Accommodator	15	11.267	1.335
Diverger	15	9.067	1.668
Assimilator	15	9.400	1.920
Converger	15	11.600	1.502

TABLE 5

Mean Scores and Standard Deviations
for Understanding Questions

	n	$\bar{X}$	SD
Conforming Environment			
Accommodator	15	8.600	2.028
Diverger	15	9.600	1.765
Assimilator	15	9.200	2.274
Converger	15	8.733	2.086
Independent Environment			
Accommodator	15	11.267	2.251
Diverger	15	9.533	2.416
Assimilator	15	8.667	2.690
Converger	15	11.733	1.944

TABLE 6

Combined Means for Learning Styles

	n	Rote	Understanding
Accommodators	30	10.100	9.933
Divergers	30	9.333	9.567
Assimilators	30	9.233	8.933
Convergers	30	10.600	10.233

A secondary analysis using post hoc Tukey's HSD tests was conducted on the rote level of questions by learning style. Comparisons were made among the possible

combinations of the four categories of learning style. Results indicated that the minimum significant difference of 1.28241 was obtained in two of the learning styles. Therefore, the second hypothesis was rejected. However, an interaction was present for the rote level of questions.

3. There will be a difference between learning environments at the rote and understanding levels of learning.

(3.1) Students in the independent environment will attain more at the understanding level of learning.

(3.2) Students in the conforming environment will attain more at the rote level of learning.

This hypothesis was tested by a paired comparison t-test by learning environments with levels of learning as the comparison variable. Results of the t-test indicate that there is no difference between rote questions (t = -2.979, $p > .5085$) and understanding levels of learning questions (t = -2.9458, $p > .0826$) for each of the learning environments (see Table 7). Therefore, the third hypothesis was not supported.

TABLE 7

Combined Means for Environments

	n	Rote	Understanding
Conforming	60	9.300	10.300
Independent	60	10.333	9.033

Summary of the Data Analysis

There were three hypotheses postulated by the study. One of the hypotheses was supported and two were rejected. Results of the data analysis demonstrated that there were significant interaction effects between learning style and learning environment on achievement scores. Although interaction effects were present for learning style and rote level of learning, interaction effects were not significant between learning style and the understanding level of learning. Finally, no differences were found between learning environments and levels of learning.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

It is generally agreed that all students do not learn in the same ways. In the case of non-credit adult education courses, the diversity among student learning styles presents an interesting challenge to the instructor. What influence does instructional strategy have on the ability of adults to learn in a particular subject area? Can instructional strategies be planned to induce a high level of achievement for most students? These questions continue to be addressed by researchers.

The concept of learning style has demonstrated some promise as a means of identifying individual difference characteristics of students. Although there is some evidence that specific learning styles "learn best" within certain conditions, it has not yet been established what relationship the type of learning style and the type of learning environment have on the ability to learn different concepts. Such information could provide insight into the design of instructional strategies for the delivery of adult education courses.

Summary

This study was designed to determine whether or not interactions occur between/among individual differences of learners with instructional treatments. Based on the theory of experiential learning, David A. Kolb's model of learning styles was used to identify individual differences in learners. The investigator sought to determine if individuals in different learning style categories would achieve more in certain learning environments, and if this matching would affect their ability to learn at different levels. It was expected that there would be interaction between learning styles and learning environment on achievement. It was also anticipated that there would be interaction between learning style and levels of learning. Finally, it was predicted that there would be a difference between learning environments and levels of learning.

Ten classes of adults enrolled in formal non-credit programs of basic computer programming were involved in the study. Based upon interviews with the instructors and observation of the classes, five of the classes were identified as conforming environments and five were identified as independent environments. Students agreeing to participate in the study completed a Learning Style Inventory, a pretest, and a biographical questionnaire during the first class session. Upon completion of the sixth class session, the students were administered a posttest consisting of

fifteen questions identified in the rote level of learning category and fifteen questions in the understanding level of learning category.

The pretest and posttest instruments were computer scored and analyzed. A packaged computer system, Statistical Analysis System (SAS), was used to summarize scores and responses for each subject. Since the total number of observations produced unequal cell sizes, a table of random numbers was used to eliminate observations in each category that exceeded fifteen. A total of 120 subjects was used in the statistical analysis.

An analysis of covariance (ANCOVA) revealed that learning style and learning environment do interact to affect achievement. However, a multiple analysis of covariance demonstrated that there were no differences between learning style and levels of learning.

It was also found that there was no difference between rote questions and understanding questions for each of the learning environments in a paired comparison t-test.

Discussion and Conclusions

Based on the results of this study, it can be concluded that the Lewinian formula, $B = f(P,E)$, provides a suitable framework for investigating the learning process in non-credit adult education courses. Both the learning style of the individual and the learning environment are

elements to be considered in the planning process of any educational situation.

It is also concluded that the determination of the learning style of students entering an educational situation can provide the instructor with valuable information for planning activities and methods that will assist each student in the learning process. Although the variable of learning environment in this study was shown to interact with learning style, environment could be more narrowly defined to determine which aspects of the environment specifically interact with learning style.

The relationship of learning style and learning environment to levels of learning was not demonstrated in this study. Although no conclusive evidence is available, the investigator would suggest additional research in this area.

The main question raised in this study is whether or not learning style and learning environment interact to affect achievement. It was predicted that subjects preferring the reflective observation mode of learning would learn best in a conforming environment and subjects who preferred the active experimentation mode of learning would learn best in an independent environment. Results of the study supported this expectation.

These outcomes are congruent with earlier investigations which have shown an interaction between learning style and learning environment (Hunt, 1975, Domino, 1968). However, the results are in direct conflict with the findings of Coop and Brown (1970). This study indicated no relation between cognitive style and achievement. Three differences exist between the present study and that of Coop and Brown (1970). First, in the present study, learning style was used as the comparison variable where cognitive style was used in the latter study. Second, achievement was measured by a comprehensive content examination developed by the researcher and the instructors in the present study while a general achievement test was administered by Coop and Brown (1970). Third, different populations were used.

Another contradiction between the present study and the Coop and Brown investigation can be noted. While the previous study found that a teacher-structured method of instruction was superior to an independent-problem solving method of instruction, the present study reported an interaction between an independent environment and a conforming environment for all learning styles. The present findings are in agreement with Robinson and Gray (1974) and Hunt (1975). It can be assumed that the inconsistency might be a result of the subject matter or system of classifying teaching method.

One unexpected finding of the present study was the lack of relationship between learning style and learning environment with levels of learning. Previous studies have found a difference between learning style and achievement at different levels of learning (Danielson and Seiler, 1979, and Coop and Brown, 1970). Two factors may be responsible. First, the posttest instrument in the present study contained thirty questions, whereas the number of questions was larger in both previous studies. A larger pool of questions would have allowed the researcher to eliminate questions indicated by an item analysis. In addition, the pretest instrument provided low reliability estimates. This could be a result of the length of the test (twenty questions) or insufficient difficulty of the questions. Second, previous studies have dealt with the media aspects of learning rather than teaching methods as a comparison variable. Further investigation into levels of learning differences by method of teaching is warranted.

Recommendations

The results of this study pose some questions for future research in the area. Although the nature of noncredit adult education courses is a limiting factor, an experimental design with random assignment to treatments would clarify the effects of learning style and learning

environment on achievement. Also, the limited duration of the courses and diversity in content certainly may have been a significant factor in the overall results.

Learning and cognitive style research is only beginning to influence the delivery of programs. Additional investigations, specifically with other populations and subject matters, are warranted to develop definitive approaches to instructional methodology.

Finally, although the results of this study did not support the achievement by levels of learning premise, future investigations may reveal this aspect of learning to be an important consideration for the design of non-credit adult education programs.

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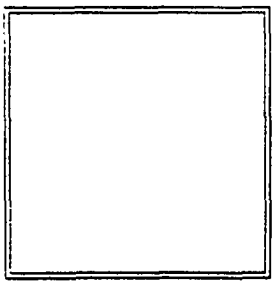
APPENDIX A

CASE WESTERN RESERVE UNIVERSITY · CLEVELAND, OHIO 44106



September 9, 1983

Rae Jean McCall
Performance Ventures
109 South Streenlead
Enid Oklahoma 73706

Dear Ms. McCall:

Thank you for your interest in the Learning Style Inventory. I can give you permission to use the LSI for research purposes, however, the McCarthy Instrument you refer to has not been validated. I would therefore suggest using the original LSI (enclosed). Please feel free to contact me (216/368-2137) if you have further questions. Your study sounds very interesting and useful.

Sincerely,

David A. Kolb

David A. Kolb
Professor

DAK/mjh

Enclosures

Department of Organizational Behavior
The Weatherhead School of Management

APPENDIX B

DIRECTIONS FOR FIRST CLASS SESSION:

1. Introductory remarks. We need your assistance. We have been asked to participate in a research project that will involve adult evening courses in BASIC Computer Programming in Area Vo-Tech Schools around the State. Although your participation is voluntary, we hope you will allow us the opportunity to work with you. Your participation will consist of three parts:

(1) a short inventory designed to reveal your predominant learning style
(2) a pre-test to determine what knowledge of BASIC programming you now have
(3) a test at the end of the sixth class session to determine what you have learned.

Your participation in this project is strictly voluntary and will, in no way, affect your certification in this class by the school.

2. First packet. If you have decided to participate in the project, your signature is needed on the top form. A code number will be assigned to you so that any information that you give us can be kept strictly confidential.

The second sheet called the "Individual Student Master Sheet" requires responses to three questions at this time: (1) age, (2) education, and (3) sex. Information concerning the Learning Style Inventory can be filled out after you have completed the next two pages.

The third page is the learning style inventory. You are asked to rank all items for number 1, then proceed to number 2, etc. Make sure that all blanks have been filled in with either a 1, 2, 3, or 4.

On the bottom of the fourth page, enter the ranking for the numbered items in each column. Then, total each column. Use the column totals to arrive at the AC - CE score and the AE - RD score. Make sure you preserve the negative sign in your score.

Plot your scores at the top of the page. The horizontal line represents your AE - RD score and the vertical line represents your AC - CE score. The quadrant in which the two scores intersect is your predominant learning style.

Now, go back to the second page to record your scores. Please turn in all four sheets. OPTIONAL: If the students

are interested in finding out what research shows about their learning style, a short description is given below.

3. True-False Pretest. Follow directions at the top of the test.

OPTIONAL: Learning Styles and their descriptions based on research. It should be stressed that there is not any style that is better than another; they are each equal.

(1) Converger. Convergers can focus on specific problems through hypothetical-deductive reasoning. They seem to do best where there is just one right answer or just one solution to a problem. Convergers are rather unemotional, and prefer to deal with things rather than people.

(2) Diverger. The exact opposite of Convergers, these people look at everything from many perspectives and organize them into a meaningful "gestalt". They are imaginative and artistically inclined. They tend to be emotional and like working with ideas in areas such as the humanities and liberal arts.

(3) Assimilator. Assimilators are very good at inductive reasoning, and in bringing together different observations into an integrated explanation. Assimilators are best at taking in data and devising theoretical models, although they are not concerned with the practical use of these models.

(4) Accommodator. Accomodators tend to rely on other people for information to a great extent, rather than their own analytical ability. They take more risks than the other three learning styles as they capitalize on their greatest asset: carrying out plans, getting involved in new experiences, and solving problems on a trial-and-error basis.

SUBJECT CONSENT FORM

I, the undersigned, agree to participate in the study entitled "Effects of Learning Style and Learning Environment on Achievement and Levels of Learning in Non-Credit Adult Education Basic Computer Programming Courses" conducted by Rae Jean McCall. I understand that the data to be collected in this study is to be used for research purposes only and that findings will be reported as group data.

It is further understood that all information collected will be treated strictly confidential by the researcher. I understand that there is no compensation for participating in the study and that I may withdraw or not participate in the study if I so choose.

_____
Signature of Subject

_____
Date

Your confidential code number is _____.

THANK YOU FOR YOUR PARTICIPATION!

INDIVIDUAL STUDENT MASTER SHEET

Demographic Information

Subject Number _____

Age (check one):
_____ 16-25 _____ 26-35 _____36-45
_____ 46-55 _____ 56 and over

Education (check highest level):
_____ less than high school graduate
_____ high school graduate
_____ some college
_____ college graduate
_____ post-graduate experience

Sex (check one): _____ male _____ female

Learning Style Inventory

CE = _____ RO = _____ AC = _____ AE = _____

AC - CE = _____ - _____ = _____

AE - RO = _____ - _____ = _____

Predominant Learning Style is (check one):

_____ Accommodator
_____ Diverger
_____ Assimilator
_____ Converger

(To be completed by researcher)

Pretest Score = _____
Rote Level Score = _____
Understanding Level Score = _____
Cumulative Score = _____

CODING SECTION (To be completed by researcher)

CODING SECTION

SN _____

AGE _____

EDUC _____

SEX _____

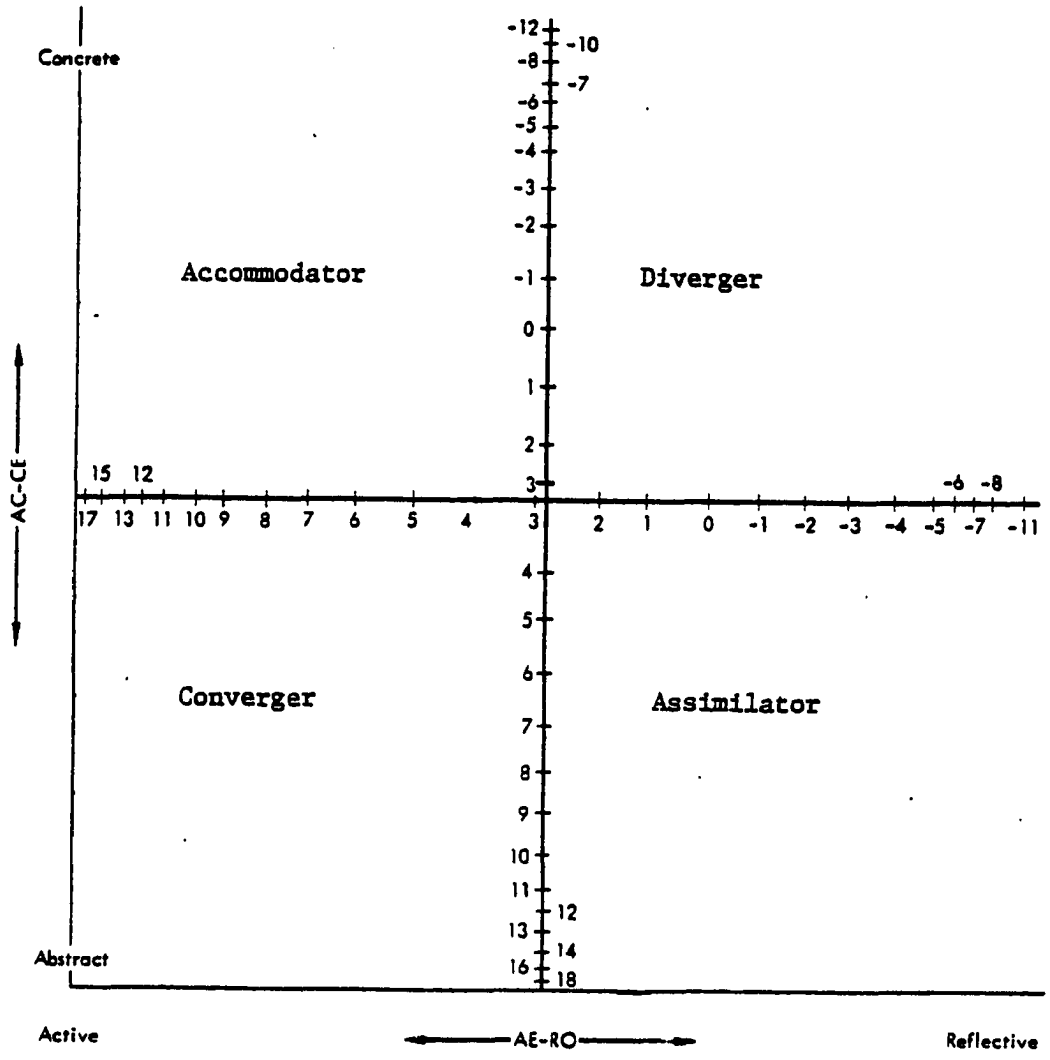
LS _____

PTS _____
RLS _____
ULS _____
CS _____

THE LEARNING STYLE INVENTORY

This survey is to determine the way you learn best. There are nine sets of four descriptions listed below. On this sheet, mark the description in each set that is most like you, second most like you, third most like you, and least like you. Assign 4 to the description that is most like you, 3 to the description that is second most like you, 2 to the description that is third most like you, and 1 to the description that is least like you. High = 4 most like you Low = 1 least like you. There are no right or wrong answers.

	CE	RO	AC	AE
1.	_____discriminating	_____tenative	_____involved	_____practical
2.	_____receptive	_____relevant	_____analytical	_____impartial
3.	_____feeling	_____watching	_____thinking	_____doing
4.	_____accepting	_____risk-taker	_____evaluative	_____aware
5.	_____intuitive	_____productive	_____logical	_____questioning
6.	_____abstract	_____observing	_____concrete	_____active
7.	_____present-oriented	_____reflecting	_____future-oriented	_____pragmatic
8.	_____experience	_____observation	_____conceptualization	_____experimentation
9.	_____intense	_____reserved	_____rational	_____responsible



Learning Style Type Grid (Copyright 1976 by David A. Kolb)

	CE	RO	AC	AE
	2	1	2	1
	3	3	3	3
	4	6	4	6
	5	7	5	7
	7	8	8	8
	8	9	9	9
TOTALS				

AC minus CE = _____ AE minus RO = _____

INTRODUCTION TO BASIC PROGRAMMING

PRETEST

Subject Number_____ Name_____

Directions: For each of the twenty questions, indicate whether the statement is true by placing a T in the space to the left of the question. If the question is false, indicate your response as F.

_____ 1. The central processing unit consists of two parts: the processor unit and main computer storage.

_____ 2. Cassette tape and floppy disk are two primary forms of auxiliary storage on a small computer.

_____ 3. The program development cycle consists of six steps: a) Review of programming specifications; b) Program design; c) Program coding; d) Program input; e) Program output; f) Program documentation.

_____ 4. A flowchart is drawn after coding the program.

_____ 5. Each programming statement coded by the programmer must be entered into main computer storage.

_____ 6. Designing, coding, and implementing a program is done after it has been documented.

_____ 7. A file consists of a group of related records.

_____ 8. A field is defined as a unit of data.

_____ 9. A trailer record is the first record in a file serves to indicate that records are ready for processing.

_____ 10. The instructions in a program may be specified in any sequence, provided they are correctly written.

_____ 11. The terminal symbol in a flowchart illustrates the start and end of the program.

_____ 12. The first statement in a loop must be the if statement.

_____ 13. A variable name which defines a numeric field may begin with either a letter of the alphabet or a number.

_____ 14. The print statement must always be followed by an if statement to test for the end of file.

_____ 15. A goto statement transfers control to the statement whose line number appears after the word GOTO.

_____ 16. Spacing, indentation, and documentation within the program are necessary only for large programs.

_____ 17. Exponentiation means raising a number to a power.

_____ 18. Parentheses are used in an arithmetic expression only for readability purposes.

_____ 19. Plus and minus signs can be included in the print using statement to edit data.

_____ 20. Initialization of variables should be completed prior to entering the main processing of a program.

APPENDIX C

CLASS SUMMARY

School _____

Title of Class _____

Beginning date _____ Ending date _____

Number of Hours _____ Meeting Times _____

Number of students _____

Instructor's Name _____

Instructor's Address _____

_____

_____

Telephone Number(s) _____

Class Category _____

Notes:

Directions to Instructors:

The following test bank is composed of possible test questions. Your assistance is needed in refining the test so that the same examination may be given in all classes. Since the short-term adult programs are of different lengths, I am asking that the content for the examination encompass only the first six class meetings.

Please review the questions and make the following judgments:

(1) At the end of the first six class meetings, will the student have exposure to the content of the question?

(2) Is one of the aternatives the correct answer?

Please select fifty (50) questions by placing an X in the answer space provided. After all instructors have had an opportunity to respond, I will eliminate the questions indicated and reproduce a test of approximately thirty questions for you to administer to your class.

I have enclosed a stamped envelope for you to use in returning the test bank to me. If you have any questions, please call me collect at (405) 242-0906.

Again, I sincerely appreciate your assistance with this research project.

Rae Jean McCall

LEVELS OF LEARNING DIRECTIONS

On the following pages, a test bank of 100 questions is given. Please read carefully the definitions for rote and understanding levels of learning listed below. You are to classify each of the 100 questions into one of three categories:

1 = Rote Level
2 = Understanding Level
3 = Neither rote or understanding

ROTE LEVEL OF LEARNING: "..the recall of specifics and universals, the recall of methods and processes or the recall of a pattern, structure, or setting. For measurement purposes, the recall situation involves little more than bringing to mind the appropriate material." (Bloom, p. 202)

Example: A programmer is:

A. The person who operates the computer.
B. The person who writes instructions for a computer.
C. The person who designs the computer.
D. Both A and B.

UNDERSTANDING LEVEL OF LEARNING: ". . . organized modes of operation and generalized techniques for dealing with materials and problems. The materials and problems may be of such a nature that little or no specialized and technical information is required. Such information as is required can be assumed to be part of the individual's general fund of knowledge. Other problems may require specialized and technical information at a rather high level such that specific knowledge and skill in dealing with the problem and the materials is required." (Bloom, p. 204)

Example: The function of an if statement is to:

A. Pass control to a stated line number if the condition being tested is true.
B. Terminate a program if the condition being tested is false.
C. Compare a value in a record to a constant which indicated the the first record has been read.
D. All of the above.

APPENDIX D

Introduction to BASIC Programming
Examination

_____ 1. Three primary units which are required on a computer in order to process data are the:

A. Input unit, the compiling unit and the storage unit.
B. Input unit, the processor unit, and the output unit.
C. Output unit, the CPU, and the output unit.
D. Coding unit, the listing unit, and the processing unit.

_____ 2. Floppy disk is a form of:

A. Main computer storage.
B. ROM.
C. Auxilliary storage.
D. Documentation.

_____ 3. An example of an arithmetic operation is:

A. Comparing two values to determine if they are equal.
B. Calculating an average score.
C. Adding a number to a total number counter.
D. Both B and C.

_____ 4. Data to be calculated must be:

A. Displayed on a CRT screen.
B. Stored in main computer storage.
C. Stored on auxiliary storage.
D. Stored on a floppy disk.

_____ 5. A flowchart is:

A. Drawn after coding the program.
B. Drawn to graphically illustrate the steps required in a program.
C. Drawn after testing the program.

_____ 6. A program that translates a BASIC program into a series of machine language instructions, called an object program, is called:

A. A compiler.
B. An Interpreter.
C. A CPU.
D. ROM.

_____ 7. A program is tested by:

A. Executing the program hundreds of times to assure that the electronic circuitry does not fail.
B. Executing the program without data to assure that there are no syntax errors.
C. Carefully reviewing the flowchart and coding prior to execution.
D. Executing the program with test data to ensure that correct output is produced.

_____ 8. A file is:

A. A unit of data within a field.
B. A group of records.
C. A series of fields.
D. A group of related characters.

_____ 9. Looping:

A. Is executing a sequence of instructions one time.
B. Is seldon required when programming.
C. May be used to allow one set of instructions to process many records.
D. Is performed by the CPU each time an instruction is executed.

_____10. A BASIC statement:

A. Must begin with a unique number that identifies that statement.
B. Can only begin with a three-digit number such as 100.
C. Cannot begin with a number greater than 100.
D. Must begin with the line number 100 and be incremented by 10.

_____11. A well documented program:

A. Contains a few REM statements.
B. Does not contain variable names.
C. Contains information which helps a reader of the program understand it.
D. Contains all REM statements.

_____12. Which statement below contains valid numeric variable names:

A. 100 READ 1A, 2B, 3C
B. 100 READ A1, B2, C3
C. 100 READ A$, B$, C$
D. 100 READ 1A, B1, C$

_____13. A string constant is:

A. A single numeric digit.
B. A series of numeric digits.
C. Any constant containing a non-numeric character.
D. Any character in a data statement.

_____14. Which of the following is a valid read statement:

A. 200 READ "A, T$, N$"
B. 200 READ "A TN"
C. 200 READ A, T$, N$

_____15. Which of the following are valid numeric variable names:

A. A1, V7, Y4
B. 1A, 7V, 4Y
C. A, V, Y$
D. A$, V$, Y$

_____16. Which of the following is a valid string variable name:

A. C1
B. C$
C. C
D. 1$

_____17. Which of the following is a valid IF statement:

A. 100 IF N$ = "END OF FILE" THEN 370
B. 100 IF N$ = END OF FILE THEN 370
C. 100 IF END OF FILE THEN 370
D. 100 IF N = "END OF FILE" THEN 370

_____18. The statement PRINT " " :

A. Will print an error message.
B. Will print a blank line.
C. Will print quotes.
D. Will cause no spacing to occur.

_____19. When a comma is used to separate variable names or constants in a print statement, each field will be displayed on the CRT screen in predetermined locations called:

A. Sectors.
B. Units.
C. Fields.
D. Zones.

_____20. The goto statement is:

A. The first statement found in a loop.
B. The last statement in a program.
C. Used to transfer control to the statement whose line number appears after the word GOTO.
D. Used to transfer control to the beginning of the program.

_____21. The end statement:

A. Is the last statement in a loop.
B. Is used to terminate a program.
C. Is used in a data statement to indicate all data has been processed.
D. Is used to document the program.

_____22. Which of the following examples is a valid statement to perform addition:

A. 100 LET T + S$ = A$
B. 100 LET M5 = W1 = W2
C. LET A = F3 = F2
D. 100 LET F3 = F2 = A4

_____23. The arithmetic operator for division is:

A. An asterisk (*).
B. A slash (/).
C. A colon (:).
D. An arrow (↑).

_____24. The output of the statement 120 PRINT "ABC"; "XYZ" would be:

A. ABC;XYZ
B. ABC
C. ABC XYZ
D. ABCXYZ

_____25. Which of the following statements could be used to count records:

A. 100 LET T1 = T1 = T1
B. 100 LET T1 = 1 = 1
C. 100 LET T1 = T1 = 1
D. 100 LET T1 = T1 * 1

_____26. Which of the following is a valid if statement:

A. 600 IF A > B THEN 660
B. 600 IF A > B, THEN 660
C. 600 A > B THEN 660
D. IF A > B THEN 660

_____27. Which of the following correctly identifies a relational operator meaning less than:

A. >
B. <
C. >=
D. < >

_____28. Which of the following correctly identifies a relational operator meaning not equal to:

A. < =
B. < >
C. < > =
D. = < >

_____29. The symbol > means:

A. Less than.
B. Greater than.
C. Equal to.
D. Not equal to.

_____30. In the following example,

```
620 IF A > 18 THEN 780
630  LET T = T + 1
```

statement 780 will be executed when:

A. The value in A is less than 18.
B. The value in A is equal to 18.
C. The value in A is greater than 18.
D. The value in A is less than or equal to 18.

APPENDIX E

APPENDIX E

Pretest Analysis by Class

Class	$\bar{X}$	S.D.	KR 20*
A	11.762	2.045	.087
B	12.235	2.157	.204
C	11.056	2.321	.304
D	12.313	1.722	.216
E	10.857	3.356	.670
F	12.000	1.826	.086
G	12.500	1.833	.116
H	13.333	1.795	.111
I	11.697	1.817	.170
J	12.091	2.151	.293

*Kuder-Richardson Formula 20 (Reliability)

Posttest Analysis by Class

Class	$\bar{X}$	S.D.	KR20*
A	10.786	1.319	.201
B	10.933	2.048	.572
C	9.444	2.217	.514
D	9.188	2.068	.432
E	9.176	2.203	.514
F	9.737	2.197	.528
G	10.000	1.633	.156
H	10.467	1.962	.156
I	10.778	1.548	.108
J	9.300	2.076	.482

*Kuder-Richardson Formula 20 (Reliability)

Posttest Analysis by Class

Understanding Level of Learning

Class	$\bar{X}$	S.D.	KR20*
A	9.850	2.414	.595
B	10.556	2.833	.721
C	11.800	2.286	.638
D	8.917	1.801	.326
E	9.316	2.493	.657
F	8.882	2.349	.571
G	9.000	2.031	.469
H	9.278	2.076	.469
I	9.667	2.675	.692
J	10.071	2.344	.617

*Kuder-Richardson Formula 20 (Reliability)

APPENDIX E

BIOGRAPHICAL SUMMARY OF SUBJECTS BY CLASS

Class	Age	Education	Sex	Pretest	Rote Questions	Understanding Questions	LS	LE
A (n=8)	2.75	3.125	.500	10.875	10.750	9.625	2.500	2
B (n=8)	2.50	3.500	.625	12.250	11.250	9.250	2.125	2
C (n=13)	3.08	2.692	.692	9.769	9.077	9.077	2.615	1
D (n=12)	2.58	3.250	.583	12.417	9.083	9.417	3.250	1
E (n=11)	2.55	2.273	.818	10.545	9.182	8.727	2.000	1
F (n=14)	2.36	2.786	.786	11.929	9.000	8.786	2.210	1
G (n=10)	2.90	3.300	.700	12.600	10.400	9.200	2.400	1
H (n=12)	3.58	3.083	.900	13.583	10.417	12.250	2.420	2
I (n=14)	3.50	3.000	.714	11.929	10.786	10.286	3.070	2
J (n=18)	2.44	2.722	.833	11.500	9.333	9.777	2.280	2

Code for Scores

Age: 1=16-25 2=26-35 3=36-45 4=46-55 5=56 and over

Education (Education Level): 1=less than high school graduate 2=high school graduate 3=some college 4=college graduate 5=post graduate experience

Sex: 0=male 1=female

Pretest: Computed Mean of Pretest Score

Rote Questions: Computed Mean of Posttest Scores (Rote Level)

Understanding Questions: Computed Mean of Posttest Scores (Understanding Level)

LS (Learning Style): 1=Accommodator 2=Diverger 3=Assimilator 4=Converger

LE (Learning Environment): 1=Conforming Environment 2=Independent Environment