AN EXPERIMENTAL INVESTIGATION OF THE RELATION BETWEEN THE INSTRUCTIONAL MODE AND THE LEARNING STYLE OF THE STUDENT

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ABSTRACT

AN EXPERIMENTAL INVESTIGATION OF THE RELATION BETWEEN THE INSTRUCTIONAL MODE AND THE LEARNING STYLE OF THE STUDENT

By

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It has been proposed that the educational process could be more efficacious if the instruction and learning materials were developed in harmony with the way in which students prefer to learn. This study was designed to measure the learning styles of the students, and to provide experimental research evidence of the effectiveness of matching the learning style of the student with an instructional mode.

The concern that motivated this study was the applicability of matching a student's learning style with an instructional mode in an educational setting that is based upon the concept of individualized instruction. The four objectives of the study were:

1. to identify the learning styles of the students in the various occupational areas at the Capital Area Career Center at Mason, Michigan;
2. to measure the effectiveness on achievement of the experimental matching of learning style with instructional mode;

3. to measure the extent to which the student characteristics of sex, age, reading comprehension level, and computational skill relate to achievement; and
4. to identify and recommend directions for ongoing and future curriculum development in the light of the measured learning styles of the students.

Approximately 100 students from the Capital Area Career Center in Michigan served as subjects for the experiment. These students were randomly selected from most of the occupational program offerings at the Center.

The preferred learning styles of the students were measured using the Learning Activities Survey. This instrument measures learning styles on two continua, concrete/symbolic and structured/unstructured.

The two selected instructional modes were direct-detailed and directed-discovery. It was felt that these modes would be compatible with the learning styles to be measured. They had the advantage of requiring little or no student-teacher interaction. A learning style-instructional mode matrix was developed to categorize the relation between style and treatment.

The learning task which was chosen related to the metric system of measurement. The instructional materials were developed in two parts: (a) conversion within the metric system, and (b) conversion between the metric and customary (English) systems of measurement.

Initial learning tests were completed immediately after instruction, and the same instruments were used five weeks later for the retention testing.

Using the results of the Learning Activities Survey, graphs were developed showing the locus of each student on the two continua, concrete/symbolic and structured/unstructured. These graphs may be readily interpreted for the learning style preference of each occupational area and the school as a whole. The study sample showed a preference for "hands-on" learning activities with a mixture of teacher-centered/student-centered learning environments.

The learning data on student achievement, when analyzed with regard to the matching of learning style with instructional mode, yielded inconclusive results. Two confounding variables were identified. Secondary hypotheses relating to the matching were posed and were not rejected.

This experimental study used a group of secondary school students enrolled in an area vocational school. The following conclusions are drawn as a result of this research.

1. It is possible to assess the learning styles of secondary school students using a relatively simple, easy-to-use questionnaire.
2. The experimental matching of learning style with instructional mode yielded inconclusive results.
3. There is a positive correlation between reading comprehension level and achieved scores when using learning materials

that are in a reading format, even though the materials are written at the sixth grade equivalent reading level.

4. There is a positive correlation between the sex of the student and achieved scores when using learning materials which concern mathematics.
5. Recommendations to the Center are:
   a. that a variety of learning styles exist among the students in each of the occupational areas and the Center may wish to consider this in developing learning environments,
   b. that the student characteristics of sex and reading comprehension level do appear to influence overall achievement as measured in this study, and
   c. that the Center should consider conducting a longer-term study before accepting or rejecting the need to consider student learning style as a factor in the development of curriculum.

The recommendation for further research is that others should continue to pursue the question: "Will students achieve better if their learning styles match the instructional mode?"

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By

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CHAPTER I

STATEMENT OF THE PROBLEM

Introduction

The need for a more concerted effort to look at the whole educational environment is upon us. In recent years, we have witnessed the rise of student unrest, the disenchantment of the public with certain aspects of education, and the push for accountability in education.

In their attempts to meet the needs of the student and the demands of the public, many educators have turned toward individualized instruction. That which has been used successfully in industrial and military training programs is now finding more application in public educational circles.

Individualized instruction may be defined as a method of instruction in which each student works alone (or in a small group), on assignments designed to meet the student's abilities, interests, and needs. The subject matter studied may be cooperatively determined by the teacher and the student. During class time, the teacher functions as an instructional manager, available to provide needed assistance or to answer questions. Individualized instruction has many facets, some of which are learning environments, instructors, learners, and courses. Most emphasis, generally, has been placed upon such factors as differentiated assignments, rate of learning, methods and media, and the goals of the educational program. Often these efforts tend to miss the core of the matter. It was Wilhelms who said, in the 1962 Yearbook of the National Society for the Study of Education, that ". . . such 'individualization' largely fails to come to grips with the fundamental differences among students--differences in their interests and purposes, their personal needs and their whole modes of thinking and learning."[1]

Writings and research studies relating to individualizing instruction are contained in the review of selected literature in the next chapter. Many recommend that instruction and learning materials should be constructed in the way that the students prefer to learn. The continued need for research on learning styles exists. Even a brief review of the literature suggests that many variables influence the acquisition of knowledge, skills, and attitudes. Unfortunately, studies on individualized instruction, as regards vocational education, dealing with the various student learning characteristics are indeed few.[2] Impellitteri and Finch write that the military training researchers are doing the majority of the studies relating to this area. They conclude that apparently vocational

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[1]F. T. Wilhelms, "The Curriculum and the Individual Differences," Individualized Instruction, The Sixty-First Yearbook of the National Society for the Study of Education, pt. 1 (Chicago: University of Chicago Press, 1962), p. 65.

[2]Joseph T. Impellitteri and Curtis R. Finch, eds., Review and Synthesis of Research on Individualized Instruction in Vocational and Technical Education (Columbus, Ohio: The Center for Vocational and Technical Education, The Ohio State University, 1971), p. 29.

educators have not been as concerned about student learning characteristics as they probably should have been.[3]

This need for more attention to the fundamental differences among students, coupled with the lack of attention given to the problem by vocational educators, creates an exciting field for research. It is hoped that this study will contribute, if only in a small way, to the solution of some of the problems, and stimulate further research in this area.

Background

The development of Area Skill Centers in the United States in recent years can be viewed as one of the results of the thinking that has occurred in educational circles. Area Skill Centers have the advantage of focusing all of the resources of a county or district on one central location. Interestingly, the instructional methods used at these centers are often not significantly different from those used in the traditional secondary school programs. Often the same instructional materials and instructional staff are used.

Among the relatively few centers using a different approach is the Capital Area Career Center in Mason, Michigan. The Center is committed to individualized instruction, having begun in 1970 as a research project in curriculum development and computer-managed instruction. Funding was provided by the Michigan Department of Education, Division of Vocational Education. The curriculum is based on the Individualized Prescribed Instruction format. Each of the

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[3]Ibid., p. 30.

occupational areas has its learning materials developed into learning packets, or mods, that are performance-objective based. Each packet consists of (1) an identification number and title; (2) a goal, or performance objective; (3) the prerequisites required to begin the mod; (4) a list of the equipment and materials needed to complete the mod; (5) a step-by-step explanation of what is to be done and exactly how to do it; and (6) a technical word-list and definitions.

Students wishing to pursue studies at the Center are helped to determine the occupation for which they are best suited by exposure to (a) an overview module, to gain an understanding of the occupational choices available to them in a chosen program of study; (b) a career decision matrix, to help the student look at the correlation between their individual values and the values of their occupational choice; and (c) a series of general learnings tests, to ascertain their proficiency in mathematics, reading, pre-employment skills (attitude/behavior), and measurement skills. After this initial exposure, the occupational choice of the student is finalized. Each student is then provided, via the computer, with an individualized listing of all the mods he/she will need to complete the selected career program. The computer also provides the student with a weekly schedule of mods to work on for that week, and, every nine weeks, prints a cumulative student progress report. Upon completion of the program, the student receives a "certificate of completion" from the Center, and a computer print-out of the tasks that he/she is qualified to perform in that occupational area.[4]

All staff members have been involved in preservice and inservice training seminars which are designed to help them function effectively as instructional managers rather than in the traditional role of a teacher. Requirements also exist for further staff development, including periodic professional-level college/university course completion and/or relevant work experience in business or industry.

Most of the mods, or learning packets, for the various occupational and supportative programs of the C.A.C.C. are written in one (direct-detailed) of the two instructional modes considered in this study. The mods are presented to the student in the form of reading materials that require a sixth grade equivalent reading level. A few modules have the step-by-step explanations of what is to be done and how to do it adapted to other media, such as audio tapes and/or slide-tape presentations. Reference to standard textbooks is also made in some mods, to aid the student in gaining the required knowledge.

The Capital Area Career Center, with its individualized instruction program, was chosen as the site for the present study. The Center has been operational since the fall semester of 1972. The personnel at the Center are concerned with the success/failure rate of the various programs. Consequently, there exists a concerted

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[4] Ingham Intermediate School District, Relevant Curriculum and Individual Progress--One Answer, A Brochure Produced by the Ingham Intermediate School District, Division of Vocational Education (Mason, Michigan: Ingham Intermediate School District, 1974).

effort to revise mods in order to make them more effective for student use. It was proposed by the researcher that perhaps one of the factors which had been overlooked was that of student learning styles.

Purpose and Objectives

Curriculum development efforts have generally focused upon developing materials suitable for the majority of the students. Those individualized programs which have been developed, in general focus upon factors other than the individual himself, such as time to complete and skills to be acquired.

More attention should be given to the individual's learning characteristics and achievement. Consideration of these factors as appropriate to individualized instruction leads to a number of questions. Three of these are:

1. What is the nature of the learning styles of the students?
2. Would matching of learning style to instructional mode improve learning?
3. What instructional modes are in use, and which are most feasible?

The concern, then, that motivated this study was the applicability of matching a student's learning style with an instructional mode in an educational setting that is based upon the concept of individualized instruction. The purpose of this study was:

1. to set up an experiment in assessing the efficiency of matching the learning styles of the students with two selected instructional modes, and

2. to assist in identifying directions for revisions of the learning materials in use at the Center.

This study was designed to provide experimental research evidence, and had as its objectives the following:

1. to identify the learning styles of the students in the various occupational areas at the Capital Area Career Center at Mason, Michigan;
2. to measure the effectiveness on achievement of an experimental matching of learning style with instructional mode;
3. to measure the extent to which the student characteristics of sex, age, reading comprehension level, and computational skills relate to achievement; and
4. to identify and recommend directions for ongoing and future curriculum development in the light of the measured learning styles of the students.

Learning style--that is, a student's preferred mode of learning--can be assessed in a variety of ways. Learning style appears to be a significant aspect of an individual's capacity to learn. The review of the literature indicated that researchers have defined various dimensions in the area of learning styles. Methods for assessing learning styles vary from the relatively simple administration of an interest inventory to the highly complex cognitive style mapping technique. The learning styles measured in this study were determined by the use of an interest inventory and were categorized as (a) concrete-symbolic and (b) structured-unstructured.

Instructional modes are the different forms that may be used to present the material to be learned to the student. Some examples of these are: (a) lecture-demonstration-discussion and (b) programmed instruction. To minimize the variables which influence the learning process, two instructional modes were chosen which require little or no student-teacher interaction. The modes selected were: (a) direct-detailed and (b) directed-discovery. Briefly defined, direct-detailed uses a step-by-step instructional format, while directed-discovery relies on the use of hints and leading questions to guide the student to discover the facts for himself.

The Research Hypotheses

Part of the intent of this study was to provide experimental evidence of the effectiveness of matching the learning style of the student with the instructional mode selected. The hypotheses that follow were developed from the consideration of the purpose and the objectives of the study.

The hypotheses which were examined in this study are:

Hypothesis 1: There is no significant difference in initial learning (knowledge of specific facts and principles, and ability to solve the problems) between students with a learning style when matched to an instructional mode and students whose learning style does not match the instructional mode.

Hypothesis 2: There is no significant difference in retention of material initially learned as measured five weeks after instruction between students with a learning style when matched to an instructional mode and students whose learning style does not match the instructional mode.

<u>Hypothesis 3</u>: There is no <u>interaction</u>[5] between the two instructional modes employed and the student characteristics of sex, age, reading comprehension level, and computational skill with regard to initial learning and retention.

The four additional variables that were examined for possible interaction with the main effect (see Hypothesis 3) are unique characteristics brought to the learning situation by each student. A fifth variable, high school grade-point average (GPA), originally considered in the proposal of this study, was discarded due to the unavailability of this statistic at the Capital Area Career Center.

Design of the Study

Individualized instruction has been heralded by some as the answer to many of the problems that face educators today. However, individualized instruction exists in many forms. This study deals with one approach, that used at the Capital Area Career Center in Mason, Michigan.

This is an experimental study, using formal research techniques for the collection and analysis of the data. It is concerned with three major topics. The first considers the assessment of the learning styles of the students. The second relates to the experimental matching of the individual's learning style with one of the selected modes of instruction and the measurement of the influence of selected learner characteristics upon overall achievement. The

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[5]Interactions are the unique effects of combination of treatments. For an explanation of the technical meaning of interaction, see W. L. Hayes, <u>Statistics</u> (New York: Holt, Rinehart and Winston, 1963), pp. 386-88.

final portion concerns the recommendations that can be made, based upon the analysis of the collected data.

The review of the literature on learning style measurement revealed that the "Learning Activities Opinionnaire," developed by John Banks (see Appendix B), showed promise as a useful tool for the purposes of this study. This instrument was designed to measure learning styles on the concrete-symbolic and the structured-unstructured continua. It was adapted in this study for use with secondary school vocational students and retitled "Learning Activities Survey" (see Appendix C).

The literature on instructional modes was researched in order to find one mode that reflected that used at the Capital Area Career Center and a second that used an opposite approach. The two instructional modes that were chosen for use in this study are the direct-detailed (similar) and the directed-discovery (opposite) methods. The instructional materials were written in each of the two instructional modes selected (see Appendix A). The content of the instructional materials was drawn from two of the mods which are currently in use in the Related Arithmetic Program at the Center.

The level of matching between the student's learning style and the instructional mode was determined on the basis of an analysis of the descriptive material available on the styles and modes. Details of the matching technique are described in Chapter III.

The population was the set of students at the Capital Area Career Center who were enrolled during the 1974-1975 school year. The students attended either morning or afternoon sessions. The sample was the set of students enrolled at the Center during the spring semester who were randomly selected for this study and for whom data were available.

The Learning Activities Survey was administered to the students in the sample. The students were then randomly assigned to one of the two instructional modes. Initial learning tests were administered upon completion of each set of learning materials. Retention tests, using the same test instruments, were administered five weeks later. Copies of the tests may be found at the end of Appendix A.

The four objectives of this study should be reached upon the review of the collected data and the analysis of the learning data. The learning styles of the students will have been described; the effect on achievement of the experimental matching will have been determined; the extent to which the selected student characteristics relate to achievement will have been measured; and recommendations for curriculum development, in the light of the measured learning styles of the students at the Capital Area Career Center, will have been made.

Assumptions and Limitations

Most endeavors are undertaken on the basis that certain underlying conditions exist. This study was based upon the following assumptions:

1. that the students used in the sample were not significantly different from the students in the population,

2. that the students were honest and sincere in their responses to the learning-style instrument,
3. that the students in the sample would be approximately evenly distributed into the several cells as measured by the learning-style instrument, and
4. that the learning materials presented in the study were considered of importance by the students.

When an experimental study is contemplated, one becomes aware of the constraints which are imposed by factors which are often outside the limits of one's control. The following limitations are the conditions within which this study was conducted:

1. The study was limited to students attending the Capital Area Career Center in Mason, Michigan.
2. The students are scheduled to attend classes at the Center in either the mornings or the afternoons. Thus, the time factor could not be made constant.
3. The physical setting of the experiment was the General Learnings Area of the Center. Students are sometimes reluctant to study in this area and this reaction may have colored their reaction to the experiment.
4. The two selected modes of instruction were a limitation on the study since many other modes of instruction exist.
5. The study was limited to attitudinal responses as indicated on a learning-style instrument ". . . whose

scope is not broad enough to cover all possible ramifications of the subject of learning styles."[6]

6. The instructional materials were presented to the student in a reading-only format; no other form of media was used.
7. The study was conducted during the months of May and June. Since many of the senior-level students are assigned to work-placement experiences during their last semester at the Capital Area Career Center, some students who had participated in the initial learning stage of the study were not available for the retention testing stage. Also, since the various home-schools finish their spring semesters at different times, some students had graduated before the study was completed.
8. The only vocational program at the CACC which requires the knowledge and use of metric measurement is that of Histologic Technician (one of the programs in the Health Occupational Area). This program does not convert measurements from English to metric or from metric to English. However, some or all of the students may have encountered or used metric measurement and/or conversion factors prior to this study.

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[6]John C. Banks, An Investigation of the Interaction of Learning Styles and Types of Learning Experiences in Vocational-Technical Education, Final Report (Menomonie, Wisconsin: Center for Vocational, Technical and Adult Education, University of Wisconsin-Stout, June 1973), p. 17.

Definition of Terms

One of the problems which may occur in any discussion is that the various participants may have differing concepts of certain key words used. In order to minimize difficulties of this nature, a list of key words and their definitions as used in this study follows.

Individualized instruction. A method of instruction in which each student works alone (or in a small group) on assignments designed to meet the student's abilities, interests, and needs. The subject matter studied may be cooperatively determined by the teacher and the student. During classtime, the teacher functions as an instructional manager, available to provide needed assistance or to answer questions.

Direct-detailed mode of instruction. All materials that the student needs to acquire and understand are presented in a carefully organized, positive, continuous, and detailed manner. Simple problems are posed to illustrate the applications of information provided, and are solved in a step-by-step fashion. Review is achieved by repetition of the material at appropriate intervals.

Directed-discovery mode of instruction. A minimum of basic information is presented in a direct manner. With the essential material as a foundation, many carefully structured and ordered questions and hints are utilized to assist the student's discovery of the remaining information and functional relationships to be acquired and understood. Sample problems, intended to illustrate the application of information, are propounded, and then leading questions are posed to suggest critical stages in their solution. Review is provided by a series of questions designed to clarify the relationships.

Learning style. Consistent patterns of behavior or activity used by the student to effectively acquire knowledge, skills, and attitudes.

Concrete style. A preference for direct, personal, and hands-on activities which use tools and materials.

Symbolic style. A preference for dealing with abstract representations of objects and phenomena to convey knowledge.

Structured style. A preference for highly organized activities with passive student involvement.

Unstructured style. A preference for self-organized and self-paced activities with active student involvement in planning.

Mod or learning packet. Each module is a short teaching unit. It provides a detailed, step-by-step procedure whereby the performance objective for each associated task can be met.

The Center or CACC. These two terms are used interchangeably throughout the study to refer to the school where the study was conducted--the Capital Area Career Center.

Initial learning. Initial learning is determined by the degree to which the student attains knowledge and skills from the instruction as measured directly following treatment. Performance objective measures are administered to each subject immediately following instruction. The amount of initial learning is indicated by the number of correct responses on these measures.

Retention. Retention, as defined for the purpose of this study, involves the recognition and/or recall of learned materials. The amount of retention is measured by the number of correct responses on the same performance objective measures as used for initial learning but which are administered five weeks after the learning period.

SMOG grading. This is a quick, easy method of assessing readability. (The term, SMOG, has no meaning, except in reference to the author's birthplace of London.) It consists of several simple operations, which may readily be used, even by untrained personnel, to ascertain the equivalent grade reading level of any printed material. Since the reader may not be familiar with the formula, it is quoted below.

1. Count 10 consecutive sentences near the beginning of the text to be assessed, 10 in the middle and 10 near the end.
2. In the 30 selected sentences count every word of three or more syllables.
3. Estimate the square root of the number of polysyllabic words counted.
4. Add 3 to the approximate square root. This gives the SMOG Grade, which is the reading grade that a person must have reached if he is to understand fully the text assessed.[7]

Succeeding Chapters

Chapter II is a review of selected literature. Learning styles are defined and various instruments used to assess the student's learning style are discussed. Findings of studies which used the two selected modes of instruction are also presented.

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[7] G. Harry McLaughlin, "SMOG Grading--A New Readability Formula," Journal of Reading 12 (May 1969): 639.

The research design, presented in Chapter III, is graphically displayed through the use of a matrix. The specific hypotheses to be considered are presented and discussed in detail, and the format used in conducting the experiment is described.

The results of the experiment and complete analysis of the data obtained are reported and discussed in Chapter IV.

The summary, conclusions, limitations, recommendations, and suggestions for further research are presented fully in Chapter V.

CHAPTER II

REVIEW OF SELECTED LITERATURE

This review of literature deals with three selected areas: the individual differences, modes of instruction, and learning styles. Each area is considered in relation to the defined purpose of this study and the interrelated questions. Sources used in the search for related literature were the Educational Resource Information Center (ERIC), Dissertation Abstracts, and a number of bibliographical compilations.

Individual Differences

Centuries ago, Plato recognized the existence of human variability, specified its social implications, and proposed tests to measure traits important to the military. We read in The Republic, II, ". . . for it comes into my mind when you say it, that we are not born all exactly alike but different in nature, for all sorts of different jobs."[1]

Comenius treated individual differences at length, admonishing teachers to consider their students' ages, intelligence, and degree of progress. He encouraged teachers to adjust methods and materials

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[1]Plato, Great Dialogs of Plato, The Republic, Book II, trans. William H. D. Rouse (New York: The New American Library, 1956), p. 166.

to the pupil's level. Children, he observed, excel in curiosity and memory, adolescents in the power to reason, and adults in abstract understanding of things.[2]

Rousseau agreed with Comenius in advocating the method of instruction through the senses, but he went further in thinking that true education consists less in knowing than in doing. His proposed teaching methods took into account those inner senses or springs of action known as feelings. The principle of interest was featured--the teacher's proper strategy lay in maneuvering the pupil into wanting to learn. So important to Rousseau were interest and inclination that he advocated a dependence upon them rather than upon constraint to sustain attention and perseverance in the face of difficulties and distractions.[3]

It was Pestalozzi who insisted that the natural instincts of a child should provide the motives for learning. He believed that free expression would allow the natural powers of the child to develop. Since it is nature that gives the drive to life, he maintained, the teacher's responsibility is to adapt instruction to each individual according to his particular, changing, unfolding nature as required at various stages of his development.[4]

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[2]Jan Amos Komensky, The Analytical Didactic of Comenius, trans. V. Jelinek (Chicago: The University of Chicago Press, 1953), pp. 159-64.

[3]Carroll Atkinson and Eugene Maleska, The Story of Education (Philadelphia: Chilton Company, 1962), pp. 62-63.

[4]Ibid., p. 72.

John Dewey has often written about men, democracy, and education. He advocated the value of the individual:

> The individual is a democratic idea. . . . Each one is equally an individual and entitled to equal opportunity of development of his own capacities, be they large or small in range. Moreover, each has needs of his own, as significant to him as those of others are to them.[5]

Dewey also writes on the value of the individual in society:

> A society based on custom will utilize individual variations only up to a limit of conformity with usage; uniformity is the chief ideal within each class. A progressive society counts individual variations as precious, since it finds in them the means of its own growth. Hence, a democratic society must, in consistency with its ideal, allow for intellectual freedom and the play of diverse gifts and interests in its educational measures.[6]

Even though secondary schools were based on democratic ideals and supported through public funds, equality of education has not become a reality. The democratic philosophy that each pupil shall be given an education that will enable him to develop to the fullest of his desires and capabilities has created many educational problems.

The clientele of our schools is composed of a myriad of individuals who come from various ethnic and socio-economic groups. These individuals vary; they vary between groups and within groups. They vary according to interests and vocational goals, age, physical health, intellectual adeptness, cognitive style, psychomotor style, achievement, motivation, attitudes and values, self-concept, empathy with other people, and patterns of interest. Yet, many educators

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[5]John Dewey, Problems of Men (New York: Philosophical Library, 1946), p. 60.

[6]John Dewey, Democracy and Education (New York: The Macmillan Company [Free Press Paper back Edition], 1966), p. 305.

attempt to provide curricula that are uniform. Charles W. Elliot, Chairman of the Committee of Ten, observed in 1892 that

> Uniformity is a curse of American schools, that any school or college has a uniform product should be regarded as a demonstration of inferiority--impairity to meet the legitimate demands of a social order whose fundamental principle is that every career should be open to talent. Selection of studies for the individual instruction addressed to the individual, . . . must come to the American school, if it is to answer the purpose of a democratic society.[7]

Theorists describe learning in terms of the average. However, basic data reveal that the course of learning may differ from student to student. Consequently, by applying general rules, we may, and often do, ignore the individual.

Jerome Bruner states, "We begin with the hypothesis that any subject can be taught effectively in some intellectually honest form to any child at any stage of development . . . no evidence exists to contradict it, considerable evidence is being amassed that supports it."[8]

In more recent years, American educators have assumed the tremendous challenge of providing educational experiences for this myriad of adolescents based on the democratic ideal. Numerous approaches have been made to provide for the individual differences of the school clientele, including individualized instruction.

Individualized instruction requires a great deal of self-direction and self-selection by the learner. It is intended to be

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[7]Robert M. Thomas and Shirley Thomas, Individual Differences in the Classroom (New York: McKay Company, 1965), p. 3.

[8]Jerome S. Bruner, The Process of Education (New York: Alfred A. Knopf, Inc., 1960), p. 33.

pupil centered, not teacher or content centered. The role of the teacher in this instructional approach is primarily that of a consultant to the learner and a manager and manipulator of the classroom environment. Wolfson cited the basic assumptions for individualized instruction as follows:

1. for real learning to occur, the learner must see the purpose and meaning in the learning experience;
2. no best method exists for all teachers to use;
3. the way the teacher interacts with the children affects the amount they learn, their feelings about learning, and their feelings about themselves, and
4. there is no best sequence in skill development.[9]

The traditional lecture-discussion method is not applicable to individualized instruction in a classroom situation. The classroom procedure will vary due to the particular learning situation and personal traits of the teacher. Wolfson observed on classroom procedure:

1. individualized instruction provides opportunity for individuals to work alone and in small groups, and
2. for individual and small group conferences with the teacher for pupil-teacher planning and evaluation and for teacher assistance as needed. In the final analysis the classroom teacher must translate his own values and goals into action.[10]

Individualized instruction is often erroneously implemented in terms of rate of learning, which allows students to complete the same assignments at varying rates. Programmed learning materials find their applications in this context. However, as Wolfson observed:

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[9]Bernice J. Wolfson, "What the Teacher Is and Does Remains the Crucial Variable in Individualizing Instruction," National Education Association Journal 55 (November 1966): 31.

[10]Ibid., p. 33.

> The use of programmed materials and textbooks with individual pacing is not truly individual learning. These materials provide for different rates of learning, but not responsible to other variations among pupils, such as, motivation, style of learning, energy level, attitudes and previous learning.[11]

Throughout man's history individual differences have been recognized. Frequently, suggestions have been made as how to capitalize on this in the educational setting. This section of the review indicates that individualized instruction, when properly implemented, appears to be the best answer to date.

Modes of Instruction

The extensive research program of Katona compared the relative effectiveness of two methods of teaching or learning on retention and transfer. The two methods which he investigated were memorizing and understanding. He concluded that problem solving which is based on understanding is superior to problem solving based on memorization.[12]

Craig studied the effectiveness of directing the learner's discovery of established relations. Initial learning for the group receiving the greater direction was superior to that of the group that learned the relationships by completely independent discovery. Thirty-one days after, the group receiving the greater direction performed better with regard to retention of learned relations. He concluded that

> this evidence indicates that teachers and experimenters should be liberal with information designed to assist learners in the discovery of principles. Large amounts of external

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[11]Ibid.

[12]G. Katona, Organizing and Memorizing (New York: Columbia University Press, 1940).

> direction now may help to insure that the learner will have an adequate background of knowledge to direct his future discovery.[13]

The relative effectiveness of reading and demonstration methods of instruction in developing scientific understanding was investigated by Boeck. He suggests that research should be conducted concerning the appropriateness of instructional methods for different levels of mental ability. He also recommends that future research should consider the crucial problem of individual differences in learning ability as it relates to the effectiveness of teaching method.[14]

In 1956, Newman reported that subjects who learned by their own study techniques performed significantly better than those taught by methods based on information provided by experimental research on learning. He concluded "that until considerable research evidence is available, the practice of allowing the student to decide on the study technique he will employ seems defensible."[15]

In the extensive literature dealing with instructional methods, one finds studies which have attempted to evaluate the effectiveness of inductive and deductive teaching methods. The inductive method depends on the gathering of observational evidence to decide whether

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[13] R. C. Craig, "Directed Versus Independent Discovery of Established Relations," Journal of Educational Psychology 47 (1956): 223-34.

[14] C. H. Boeck, "The Relative Efficiency of Reading and Demonstration Methods of Instruction in Developing Scientific Understanding," Science Education 40 (1956): 92-97.

[15] S. E. Newman, "The Design of Materials and Procedures for Learning," American Psychologist 11 (1956): 380 (abstract).

the hypothesis under consideration is to be accepted or rejected. The deductive method uses a process of drawing conclusions through a chain of valid reasoning (based on assumptions accepted as true).

As an example of this, Michael studied the relative effectiveness of the inductive and deductive methods used in the teaching of algebra. Students using the deductive method were given rules by the teacher, followed by repetition and practice. The inductive method was used with the other group of students, who were expected to discover and understand the basic principles and relationships taught. Although the findings were not statistically significant, Michael reported it appeared that the deductive method was more effective with students of average and high ability, and the inductive method seemed superior for the slow learners.[16]

Sobel, in a more recent investigation along the same lines as Michael, found the inductive method superior for students with above-average mental ability in learning concepts and skills in algebra. He used two groups of high school students, divided into (1) a control group, for which an abstract, verbalized, deductive method was used, with concepts defined and presented by the teacher, followed by practice exercises; and (2) an experimental group, with whom he used a concrete, nonverbalized, inductive procedure with the student being guided through experiences involving applications to discover and verbalize concepts. Sobel's conclusion was that brighter students

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[16]R. E. Michael, "The Relative Effectiveness of Two Methods of Teaching Certain Topics in Ninth Grade Algebra," The Mathematics Teacher 42 (1949): 83-87.

profit in the learning of certain algebraic concepts and skills when the experimental method was used with them.[17]

It is not surprising that conflicting research evidence exists, since a variety of factors enter into any investigation. One of the problems may well be the names given to the method of teaching which is used. The need for additional well-planned and carefully controlled experimentation is evident.

One of the areas similar to the present study is that of problem solving. Although there is an extensive body of literature in this area, no exhaustive review has been made.

The work of Thorndike, however, has some direct bearing upon the present study. He points out that what may be considered to be a problem by a teacher may not be so by a student. The educator's concern should be to make use of the real problems in the student's life. He should attempt to encourage the student to become aware of worthwhile goals, so as to create interest in problems important to his future life.[18]

Thorndike states that good educational programs take into account both practical problems and intellectual problems. These should be presented in a form which the student will accept as his own.[19]

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[17]M. A. Sobel, "A Comparison of Two Methods of Teaching Certain Topics in Ninth Grade Algebra," Dissertation Abstracts 14 (October 1954): 1647.

[18]R. L. Thorndike, "How Children Learn the Principles and Techniques of Problem-Solving," Learning and Instruction, Forty-Ninth Yearbook of the National Society for the Study of Education, pt. 1 (Chicago: University of Chicago Press, 1950), pp. 192-216.

[19]Ibid., p. 195.

This directs one to the demands of students today, to make education relevant for them.

No discussion of problem solving would be complete without reference to John Dewey. Among his many writings one finds extensive discussion of the way man thinks and solves problems. Dewey's familiar five steps to problem solving are (1) a felt difficulty, (2) its location and definition, (3) suggestion of possible solution, (4) development by reasoning of the bearings of the suggestion, and (5) further observation and experimenting leading to its acceptance or rejection.[20]

Although many research scientists may function in such an orderly fashion, young people are more likely to test some "hypothesis" that they may hold, and if it proves inadequate, return to the stages of further definition and clarification. Even students who have been exposed to the "scientific method," as it is sometimes called, will often continue to use a thought process which is rather individual.

Dewey was well aware of this, and he commented about the use of the steps thus:

> The disciplined, or logically trained mind--the aim of the educative process--is the mind able to judge how far each of these steps needs to be carried in any particular situation. . . . The trained mind is one that best grasps the degree of observation, forming of ideas, reasoning, and experimental testing required in any special case. . . . What is important is that the mind should be sensitive to problems and skilled in methods of attack and solution.[21]

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[20]John Dewey, How We Think (Boston: D. C. Heath, 1910), p. 72.

[21]Ibid., p. 78.

The ability to solve problems is perhaps one of the greatest goals of the educational process. Instructional approaches to develop this ability are many and diverse. Two of the possible instructional techniques or modes are considered in this study.

The following literature reviews relate to the two instructional modes used in this study, that of (1) direct-detailed and (2) directed-discovery. One of the earliest industrial education research settings to use the two modes of instruction is contained in the experimental study conducted by Willis E. Ray. In his work with students in junior high school industrial arts, Ray studied

> . . . the effect of directed-discovery, in situations providing numerous problem-solving opportunities, upon initial learning, retention, and transfer of micrometer measurement principles and skills as compared with traditional direct and detailed instruction in these situations, with three levels of intelligence.[22]

Ray used two experimental teaching methods and one control group, and three levels of mental ability assumed to be related to the criterion. Controlled variables were (1) content and method of presentation, (2) length of instruction, (3) illustrations, (4) precision measuring equipment, and (5) testing and testing conditions. One tenable hypothesis was stated, "There is no interaction between the two teaching methods employed and the low, average, and high intellectual levels with regard to initial learning, retention, and transfer of learning."[23]

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[22] Willis E. Ray, "An Experimental Comparison of Direct and Detailed and Directed Discovery Methods of Teaching Micrometer Principles and Skills" (Ed.D. dissertation, University of Illinois, 1957), p. 6.

[23] Ibid., p. 7.

The conclusions reached in the study were that

> (1) The direct and detailed and directed discovery methods of teaching are equally effective with regard to initial learning of micrometer principles and skills. (2) The direct and detailed and directed discovery methods of teaching are equally effective with reference to retention of material initially learned as measured one week after instruction. (3) The directed discovery approach to teaching is superior to direct and detailed instruction with respect to retention of material initially learned as determined six weeks after instruction. (4) The directed discovery method of teaching is more effective than the direct and detailed approach in enabling students to make wide applications of material learned to new and related situations, both at one and six weeks after instruction. (5) There is no interaction of teaching method and intellectual level.[24]

It came as a complete surprise to the experimenter that there was a complete absence of any indication of interaction. Ray thought prior to the experiment that the directed-discovery method would be superior to the direct and detailed method for the exceptionally bright, and the reverse for the slow learner.[25]

Although the experiment was conducted under controlled conditions and does contain some limitations, application to other learning situations should be possible. Ray concludes with the implication that

> . . . teachers who use techniques which lead students to discover relationships and draw conclusions from their own discovery may provide the opportunity for them to apply their learning more effectively to new situations and to retain more of what they initially learn.[26]

During the early 1960's, a number of studies were completed using these two methods of instruction in a variety of teaching areas. Grote used the two methods in teaching selected principles of physics to high school students. He states that

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[24]Ibid., p. 65. [25]Ibid., p. 60. [26]Ibid., p. 70.

> . . . the discovery method, as used in this study, placed a major responsibility upon the subject as an active participant in the study of meaningful material, while the direct-detailed method considered the subject as a less active participant in the learning process.[27]

He found that although the directed-discovery method was superior on the first initial learning test, no difference was measured on later tests. There was a difference in achievement found on the basis of the sex variable--male subjects were superior (with directed-discovery method) as measured by the criterion test.[28]

Moss used the two methods of instruction with high school Industrial Arts-Graphics students. He used a tape-recorder to present the instructional material to the two experimental groups. Thus the order of content and length of time devoted to each item of information could be controlled. Moss concluded that there was no advantage in using direct-detailed or directed-discovery methods when the material taught was nonmanipulative.

Technical content was drawn from the area of letterpress imposition. No significant differences were found on nine sets of measures representing pertinent experimental characteristics: (1) I.Q. scores, (2) chronological age, (3) mechanical drawing grade, (4) average grade in Industrial Arts courses, (5) "personality" rating, (6) previous

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[27]C. N. Grote, "A Comparison of the Relative Effectiveness of Direct-Detailed and Directed Discovery Methods of Teaching Selected Principles of Mechanics in the Area of Physics" (Ed.D. dissertation, University of Illinois, 1960), p. 9.

[28]Ibid., p. 112.

printing experience, (7) previous imposition experience, (8) years of parental schooling, and (9) grade placement.[29]

Rowlett applied the two methods to the area of Industrial Arts-Drawing, in teaching the concepts of orthographic projections: high, average, and low-ability groups were the independent variables; while initial learning, retention, and transfer at specified intervals were the dependent variables. After comparing test results, the author concluded that effective learning can be accomplished by either method.[30]

In 1962 Suess completed his experimental study, which was a replication of Rowlett's work with the addition of the varying degrees of manipulation on the directed-discovery method. The students in the sample were randomly assigned to one of four groups. Two of these groups were urged to "visualize" in the instructional session, while the other two groups were given scale-model blocks to manipulate while completing workbook exercises. Suess concluded that there was no difference in achievement as a result of the amount of manipulation as measured by initial learnings test, or on subsequent retention tests administered twelve days and six weeks later.[31]

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[29] J. Moss, Jr., "An Experimental Study of the Relative Effectiveness of the Direct-Detailed and the Directed Discovery Methods of Teaching Letter-Press Imposition," Dissertation Abstracts 21 (April 1961): 2992.

[30] J. D. Rowlett, "An Experimental Comparison of Direct-Detailed and Directed Discovery Methods of Teaching Orthographic Projection Principles and Skills" (Ed.D. dissertation, University of Illinois, 1960).

[31] A. R. Suess, "An Experimental Study Comparing the Effectiveness of Varying Degrees of Manipulation on the Directed Discovery Methods of Presenting Orthographic Projection," Dissertation Abstracts 23 (May 1963): 4269.

The application of the direct-detailed and directed-discovery methods of instruction to industrial arts electricity was studied by Brenner. He used 120 college students in his study sample, who were enrolled in a basic electricity course and involved in the six laboratory sections. Random assignment of the two sections to the two methods of instruction was used. Brenner found the directed-discovery method significantly superior with regard to the electrical problem-solving performance of low-ability students. Both methods appeared to be equally effective for technical information learning, influencing student attitude toward electricity, and retention of the cognitive content.[32]

Much has been written regarding the effectiveness of several modes of instruction. Research evidence exists to support one method over another. Two modes that appear quite applicable to individualized instruction are direct-detailed and directed-discovery. These modes yield themselves to minimal student-teacher interaction in the learning situation. Therefore these modes were chosen to be used in this experimental study.

Learning Styles

The term "style" is of common usage today, but carries with it connotations that are different for different people. One may refer to a person's style of living, speaking, or learning. To give some perspective to the term as used in this study, this section will

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[32]C. J. Brenner, "An Experimental Comparison of Direct-Detailed Versus Directed Discovery Laboratory Exercises in Teaching Selected Elements of Basic Electricity" (Ed.D. dissertation, University of Missouri, 1968).

(1) review different definitions of style, (2) list types of learning styles, and (3) review related research on styles that affect teaching and learning.

Definition of Style

Learning style was defined by Taba, Levine, and Freeman[33] as modes of thought which an individual employs rather persistently in a variety of different cognitive tasks. De Cecco[34] viewed learning styles as the personal ways an individual processes information in the act of learning new concepts and principles.

In their investigations of relationships between learner characteristics and methods of instruction, Tallmadge and Shearer define learning style as ". . . an attribute of an individual which interacts with instructional circumstances in such a way as to produce differential learning achievement as a function of their circumstances.[35]

In a number of studies, the term cognitive style appears to be used in the same sense as learning style. Kagan, Moss, and Sigel defined cognitive style as ". . . a term that refers to stable individual preferences in mode of perceptual organization and conceptual

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[33]H. Taba, S. Levine, and F. E. Freeman, Thinking in Elementary School Children (San Francisco: San Francisco State College, 1964), p. 8.

[34]J. P. De Cecco, The Psychology of Learning and Instruction (Englewood Cliffs: Prentice-Hall, Inc., 1968), pp. 75-76.

[35]C. K. Tallmadge and J. W. Shearer, "Relationships Among Learning Styles, Instructional Methods, and the Nature of Learning Experiences," Journal of Educational Psychology 60, 3 (1969): 222.

categorization of the external environment."[36] Hill and Nunney have done extensive work with cognitive style mapping, and they define a student's cognitive style as being ". . . determined by the way he takes note of his total surroundings--how he seeks meaning, how he becomes informed."[37] Hester and Tagatz write that "cognitive style can be considered an inherent organism's variable, the qualitative aspects of which are stable, while the quantitative aspects increase with the individual's developments."[38]

In a publication by Rosenberg, learning style is defined as follows:

> If a person is observed in a number of different problem-solving situations, a modal pattern of behavior can usually be ascertained. It is this modal pattern of his behavior that he refers to as his style.[39]

Banks, in his study of the interaction of learning styles, concluded that

> Considering all facets of the research on cognitive style, mapping and learning style, an operational definition for learning style is suggested to be: consistent patterns of behavior or

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[36] J. Kagan, H. A. Moss, and I. E. Sigel, "The Psychological Significance of Styles of Conceptualization," in Basic Cognitive Processes in Children, ed. J. F. Wright and J. Kagan; Monograph of the Society for Research in Child Development 28 (1963): 73.

[37] J. E. Hill and D. W. Nunney, "Career Mobility Through Personalized Occupational Education," American Vocational Journal 46 (1971): 38.

[38] F. M. Hester and G. E. Tagatz, "The Effects of Cognitive Style and Instructional Strategy on Concept Attainment," The Journal of General Psychology 85 (1971): 230.

[39] M. B. Rosenberg, Diagnostic Teaching (Seattle: Special Child Publications, 1968), p. 22.

activity preferred and employed by the individual to effectively and efficiently acquire knowledge, skills and attitudes.[40]

Learning style appears to be a significant aspect of an individual's capacity to learn. Methods of assessing an individual's learning style exist. An aspect of the present study was an attempt to determine if matching between a student's learning style and instructional mode could be effectively performed.

Types of Learning Styles

In any research dealing with the subject, the definition of learning style becomes an all-encompassing feature. Many researchers have isolated and defined the various dimensions in the area of learning styles. Among these, Kagan, Moss, and Sigel refer to three basic cognitive styles--analytic-descriptive, relational-contextual, and inferential-categorical--which are based on children's and adults' performances in grouping and sorting tasks.

The analytic-descriptive individual prefers to split the stimuli in his environment into parts and to attend to these in units. They differentiate these units in the formation of categorizations.

The relational-contextual individual chooses to characterize objects in the environment on the basis of a functional relationship that may exist among the objects.

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[40] J. C. Banks, "An Investigation of the Interaction of Learning Styles and Types of Learning Experiences in Vocational-Technical Education," Final Report (Menomonie, Wisconsin: Center for Vocational, Technical and Adult Education, University of Wisconsin-Stout, 1973), p I-7.

The inferential-categorical individual prefers to form his categories on the basis of inferences made about the stimuli that he groups together.[41]

Cognitive interest styles relating to vocational interests have been formulated by Holland as a result of his experiences as a vocational counselor and clinician. He writes:

> After reviewing the vocational literature--especially factor analytic studies of personality and vocational interests--I concluded that it might be useful to categorize people into six types: Realistic, Intellectual, Social, Conventional, Enterprising and Artistic.[42]

Each of the styles is composed of personal qualities that create predispositions for a particular class of vocations. The assumption was that a person would be in a vocational field that fitted his predisposition and vocational style.

The realistic-style individual copes with his physical and social environment by selecting goals, values, and tasks that entail the objective, concrete valuation and manipulation of things, tools, animals, and machines. He prefers agricultural, technical, skilled trade and engineering vocations, but avoids supervisory and leadership roles. He likes activities that involve motor skills, things, realism, and structure.

The intellectual-style person copes with the physical and social environment through the use of intelligence; he solves problems primarily through the manipulation of ideas, words, and symbols.

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[41]Kagan, Moss, and Sigel, "Psychological Significance," p. 76.

[42]J. L. Holland, The Psychology of Vocational Choice (Waltham, Mass.: Blaisdell, 1966), p. 15.

Preference is for the academic and scientific areas. Activities that involve analytic and imaginative behavior are the forte of this style.

The social-style individual copes with his environment by selecting goals and tasks in which he can use his skills with an interest in other persons in order to train or change their behavior. Vocations preferred by social individuals are of an educational, religious, or therapeutic nature. He prefers activities involving religious, social, and esthetic expression, and concerns himself with human welfare.

The conventional-style person copes with his environment by selecting goals, tasks, and values that are sanctioned by custom and society. He prefers occupations that are structured and role oriented, such as clerk, accountant, and appraiser. Activities involving clerical and computational tasks are well-liked.

The enterprising-style person is one who copes with his world by selecting goals, tasks, and values through which he can express his adventurous, dominant, enthusiastic, energetic, and impulsive qualities. His preference is for business roles and activities at the supervisory level. Activities in which he can make use of his persuasive, self-confident, extroverted nature are preferred.

The artistic-style individual copes with his physical and social environment by using his feelings, emotions, intuitions, and imagination to create art forms or products. He prefers occupations which involve his design and conducting skills. Preference is for activities wherein he can use his independence of judgment and originality.[43]

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[43]Ibid., pp. 16-35.

Johnson and Moore found the discriminatory efficiency of the six Vocational Preference Inventory scales (of Holland) for the technical-vocational sample of students relatively impressive. In their study, 59 percent of the trainees were correctly assigned on the basis of VPI profiles.[44]

In his book, Diagnostic Teaching, Rosenberg identified four learning styles:

1. Rigid inhibited--a tightly closed system for processing information such that both intrapersonal and extrapersonal sources of information are suppressed.
2. Undisciplined--a person who tends to be overly sensitive to intrapersonal sources of information and has not learned to effectively utilize extrapersonal sources.
3. Acceptance Anxious--a person tending to be overly sensitive to extrapersonal sources of information and who has not learned to effectively utilize intrapersonal sources.
4. Creative--a person who has learned how to harmonize the utilization of both extrapersonal and intrapersonal sources of information such that maximum utilization can be made of both learning activities.[45]

According to Rosenberg, a person's style depends upon two dimensions of his information-processing ability: (a) locus of information and (b) level of symbolization. The first involves the degree of openness for information from within and outside the learner. The second relates to the level of abstraction the learner can manage symbolically in problem-solving situations.[46]

Rosenberg hopes that the teacher will be able to use his classification of students in (a) anticipating how the student will relate

[44] D. M. Johnson and J. C. Moore, "An Investigation of Holland's Theory of Vocational Psychology," Measurement and Evaluation in Guidance 5 (January 1973): 493.

[45] Rosenberg, Diagnostic Teaching, pp. 33-61.

[46] Ibid., p. 63.

intrapersonally, and (b) anticipating how the student is likely to select, integrate, and act upon information presented to him in a learning situation.[47] Commenting upon the three components of diagnostic teaching, Rosenberg writes that the teacher should:

1. possess a clear teaching objective and knowledge of steps necessary to reach that objective.
2. thoroughly assess the individual differences that significantly influence the child's learning abilities. This includes assessment of his learning style.
3. "harmonize" the curriculum with the unique competences, needs and interests of each child.[48]

Oen, while directing a learning styles project, wrote:

> In order to truly individualize the learning situation, one must assess all characteristics of an individual, be aware that different characteristics exist in all students, and be competent in making value judgments that affect learning based on these variables.[49]

In this vein, the most elaborate and comprehensive undertaking found in this search of related literature is the work of Hill and Nunney at Oakland Community College. Hill describes their program and the use of cognitive style as follows:

> Oakland Community College accepts the premise that no two students seek meaning in exactly the same manner. We believe that . . . students can learn . . . if the teaching methods and media are adjusted to the students' educational cognitive style. The College maps the cognitive style of each student to provide a picture of various ways in which he searches for meaning. . . . This information can be used to build a personalized program of instruction.
>
> Results from a battery of tests and inventories are processed through the College's computer system to produce a map of cognitive traits that describe the many ways each student might seek meaning. Cognitive maps are printed out in the form

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[47]Ibid., p. 65. [48]Ibid., p. 21.

[49]U. T. Oen, "Investigating the Interaction of Learning Styles and Types of Learning Experiences in Vocational-Technical Education," Interim Report (Appleton, Wisconsin: Fox Valley Technical Institute, 1973), p. 22.

> of a Cartesian product of three sets. The first set indicates a student's tendency to use certain types of symbols. The second set indicates influences which the student brings to bear in deriving meaning from symbols. The third set indicates the manner in which he reasons. A maximum of 2,560 different profiles of these elements are possible for an individual to show in his map at a given level of educational development.[50]

Their system uses two types of symbols, theoretical and qualitative, which are considered basic to the acquisition of knowledge and meaning. There are four theoretical factors:

1. Theoretical Visual Linguistic--written words
2. Theoretical Auditory Linguistic--spoken words
3. Theoretical Visual Quantitative--written numbers
4. Theoretical Auditory Quantitative--spoken numbers

There are twenty qualitative factors:

1. Auditory--ability to perceive meaning through the sense of hearing
2. Olfactory--ability to perceive meaning through the sense of smell.
3. Savory--ability to perceive meaning through the sense of taste
4. Tactile--ability to perceive meaning through the sense of touch
5. Visual--ability to perceive meaning through the sense of sight
6. Proprioceptive--ability to synthesize a number of symbolic mediations into a performance demanding monitoring of a complex task [This is sometimes referred to as the sixth sense. There are four subcategories, identified as Dextral, Kinematics, Sinestral, and Temporal.]
7. Code Empathetic--sensitive to the feelings of others
8. Code Esthetic--ability to enjoy the beauty of an object or idea
9. Code Ethic--commitment to a set of values, a group of principles, obligations and/or duties
10. Code Histrionic--ability to exhibit a deliberate behavior, or play a role to produce some particular effect on other persons
11. Code Kinesics--ability to understand, and to communicate by, non-linguistic functions such as facial expressions and motions of the body
12. Code Kinesthetic--ability to perform motor skills, or effect muscular coordination according to a recommended, or acceptable, form

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[50]J. E. Hill and D. N. Nunney, "The Educational Sciences" (Bloomfield Hills, Michigan: Oakland Community College, 1971), p. 3.

13. Code Proxemics--ability to judge the physical and social distance that the other person would permit, between oneself and that other person.
14. Code Synnoetics--personal knowledge of oneself
15. Code Transactional--ability to maintain a positive communicative interaction which significantly influences the goals of the persons involved in that interaction
16. Code Temporal--ability to respond or behave according to time expectations imposed on an activity by members in the role-set associated with that activity[51]

In addition, Hill has identified three cultural determinants of the meaning of symbols: (1) individuality, (2) associates, and (3) family. There are also five forms or modalities of inference mapped, that the individual uses in the process of deriving meaning. These modalities of inference are: (1) Magnitude, (2) Difference, (3) Relationship, (4) Appraisal, and (5) Deductive.[52]

The cognitive style map of an individual is derived from these multiple inputs. The individual's mode of behavior, in search for meaning, or cognitive style, is represented by a Cartesian product.

$$G = S \times E \times H$$

where G = the Cartesian product
S = symbols and their meaning
E = cultural determinants of the meanings of symbols
H = modalities of influence

The purpose of determining an individual's orientation in each of the three sets making up cognitive style is to determine his strengths at a given level of educational development. This diagnosed cognitive style then provides information for the teacher and the

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[51] J. E. Hill and D. N. Nunney, "Personalizing Educational Programs Utilizing Cognitive Style Mapping" (Bloomfield Hills, Michigan: Oakland Community College, Revised 1974), pp. 4-5.

[52] Ibid., p. 5.

student to prescribe specific instructional activities that insure with high probability that the student will successfully accomplish a specific educational task.[53]

The Structure-of-Intellect model (see Figure 1) developed by Guilford identified styles which may have applicability to education. He states that

> . . . we might well undergo transformations with respect to our concept of the learner and the process of learning. Under the prevailing conception, the learner is a kind of S-R device, much on the order of a vending machine. You put in a coin, and something comes out. The machine learns what reaction to put out when a certain coin is put in.
>
> If, instead, we think of the learner as an agent for dealing with information, where information is defined broadly, we have something more analogous to an electronic computer. We feed a computer information; it stores that information; it uses that information for generating new information, either by way of divergent or convergent thinking; it evaluates its own results.
>
> We do not know to what extent each factor is determined by heredity and to what extent by learning. The best position for educators to take is that possibly every intellectual factor can be developed in individuals at least to some extent by learning.[54]

Guilford identifies four kinds of intelligence, two of them being called Figural (concrete)/Symbolic (signs). Those abilities involving the use of figural information may be regarded as concrete intelligence. Abilities important to learning to recognize words, to spell, and to operate with numbers may be regarded as symbolic intelligence.[55]

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[53]C. M. Lange, "A Study of the Effects on Learning of Matching the Cognitive Styles of Students and Instructors in Nursing Education" (Ph.D. dissertation, Michigan State University, 1972), pp. 20-22.

[54]J. P. Guilford, "Three Faces of Intellect," <u>The American Psychologist</u> 14, 8 (1959): 478.

[55]Ibid., pp. 477-78.

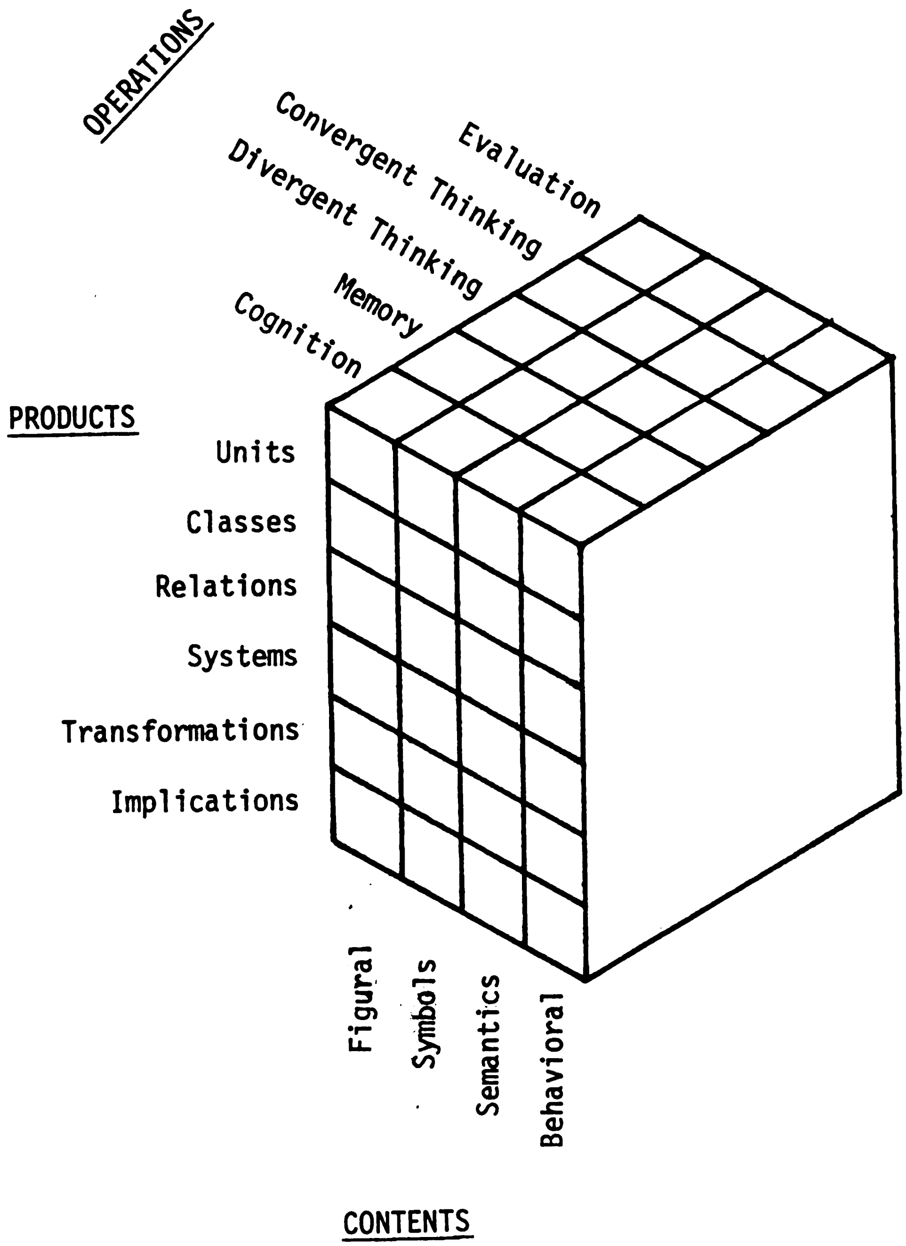

Fig. 1.--Structure-of-Intellect model.

Thelearning styles, used in this present study, are based upon the work of John Banks, previously with the University of Wisconsin-Stout. He developed a matrix of some of the styles which he felt had applicability to vocational-technical education. The matrix (see Table 1) provides information on the various behavioral characteristics for a given learning style and possible instructional mode to accommodate the given style.

The definitions which Banks used for each of the style dimensions are:

> Learning Style--Consistent patterns of behavior or activity preferred and employed by the individual to effectively and efficiently acquire knowledge, skills and attitudes.
>
> Concrete Style--A preferred learning strategy employed by the individual where optimum learning is affected by that individual in a situation that allows the learner to become personally and actively involved with an object or in direct contact with phenomena in "hands on" experience.
>
> Symbolic Style--A preferred learning strategy employed by the individual where optimum learning is affected by that individual in a situation that allows the learner to engage in a wide variety of mediated, computational, reading or verbal interaction to achieve learning.
>
> Structural Style--A preferred learning strategy employed by the individual where optimum learning is affected by the learner in a highly organized situation. The sequence and form of instruction are determined prior to engaging in the learning activity.
>
> Unstructured Style--A preferred learning strategy where optimum learning is affected by the learner in an unorganized situation. The student utilizes a random pattern of personal selection and involvement in learning activities and objectives and a specific sequence are avoided.[56]

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[56]Banks, "An Investigation," p. I-16.

Table 1.--Behavioral activity characteristics representing selected learning styles and possible instructional modes to accommodate the styles.

Learning Style Dimension	Behavioral Activity Characteristics Representing Style	Recommended Instructional Modes for the Style
1.1-Concrete	1.1.1-Likes to deal with objects with "hand-on" activities 1.1.2-Deals directly with phenomena 1.1.3-Personal involvement 1.1.4-Employs use of tools, materials & equipment	1.1.1-Laboratory activities 1.1.2-Experiments 1.1.3-Group activity 1.1.4-Object involvement (project) 1.1.5-Mediated tutorial
1.2-Symbolic	1.2.1-Prefers to deal with abstract representation of objects to convey learning	1.2.1-Computations 1.2.2-Verbal activity 1.2.3-Mediated instruction 1.2.4-Language and reading activity
2.1-Structured	2.1.1-Prefers to participate in highly organized activities from simple to complex 2.1.2-Passive student involvement in planning & organizing student activities	2.1.1-Entire course sequence and content specified for the student
2.2-Unstructured	2.2.1-Prefers no definite pattern of classroom organization 2.2.2-Self-pacing 2.2.3-Active student involvement in planning & organizing activities 2.2.4-Prefers to "plan" his own activities	2.2.1-Self-guided instruction 2.2.2-Student selection of content and objectives 2.2.3-Self-sequence with few guidelines

Related Research on
Teaching and Learning

Studies that differed in design and use of instructional methods as a function of learner characteristics have reported conflicting results.

Tallmadge and Shearer conducted a study to determine whether training effectiveness could be increased by using various instructional methods as a function of identifiable student characteristics. It was found that interactions between instructional methods and learner characteristics were not statistically significant.[57]

Tuckman studied the effectiveness of matching teaching style with student style. He hypothesized that a directive teaching style would be more effective with concrete, authoritarian students and a nondirective teaching style would be more effective with abstract, nonauthoritarian students. The findings showed that all students were more satisfied with, preferred, and earned higher grades from nondirective teachers in both vocational and nonvocational subjects.[58]

The relationship between selected personality variables and learner academic performance under two methods of instruction (programmed and conventional) was studied by Haskell. An attempt was made to determine what unique contribution the personality characteristics

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[57]G. K. Tallmadge and J. W. Shearer, "Relationships Among Learning Styles, Instructional Methods, and the Nature of Learning Experiences," Journal of Educational Psychology 60, 3 (1969): 228.

[58]B. W. Tuckman, "A Study of the Effectiveness of Directive Versus Non-Directive Vocational Teachers as a Function of Student Characteristics and Course Format," Final Report (New Brunswick, New Jersey: Rutgers, The State University, September 1968), p. 89.

of learners made toward facilitating or retarding achievement when adjustment was made for the effects of general mental ability. No significant differences were found in the mean achievement of groups who received the various treatments. Haskell concluded that

> . . . programmed instruction appeared to hold promise for students who were agreeable and easy to get along with and/or who were inclined to be slow and methodical, while those who were more likely to be characterized as aggressive appeared to perform better under conventional instruction.[59]

Hester and Tagatz concluded that the mode of individual concept formation--i.e. cognitive style--is an important dimension of individual differences in cognitive functioning. Their study indicated that individuals can be instructed in a manner consistent with their cognitive style.[60]

Lange used the "Cognitive Style Mapping" of Hill and Nunny in her study of matching students and instructors. She concluded that matching does not significantly change the failure-withdrawal rate of students in nursing education. Matched students do, however, perceive their instructors more positively and achieve higher mean scores than do nonmatched students. Lange also reported that the students'

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[59]Roger W. Haskell, "Effect of Personality Characteristics Upon Learning Via Selected Modes of Instruction--An Experimental Investigation," in Review and Synthesis of Research on Individualizing Instruction in Vocational and Technical Education, ed. J. T. Impelliteri and C. R. Finch (Columbus, Ohio: The Center for Vocational and Technical Education, The Ohio State University, 1971), p. 27.

[60]F. M. Hester and G. E. Tagatz, "The Effects of Cognitive Style and Instructional Strategy on Concept Attainment," Journal of General Psychology 85 (1971): 237.

cognitive maps do change over time, based on the numerical analysis of the cognitive style maps for students who were "re-diagnosed."[61]

John Banks developed an instrument (see Appendix B) to measure a student's learning style on two continua--concrete/symbolic and structured/unstructured. He concluded

1. that learning style is a measurable and definite variable as it relates to effective and efficient learning,
2. that the final instrument can effectively determine an individual's learning style, and
3. that student learning styles should be an important consideration in attempting to individualize instructional programs.[62]

The final section of this review was related to learning styles. Several different definitions were presented along with a discussion of types of learning styles from different perspectives. Although research does exist with regard to the use of learning styles in the teaching and learning environment, none was located that paralleled the proposed experimental matching of this study. The work of Banks and Oen, however, yielded valuable information for the present study.

Summary

This review of literature has dealt with three selected areas: the individual, modes of instruction, and learning styles. The first section dealt with individual differences. Several different approaches or methods of instruction were suggested. Individualized instruction, when properly planned, implemented, and managed, appears to hold the

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[61]Lange, "A Study of the Effects," pp. 117-22.

[62]Banks, "An Investigation," pp. III-53, III-54.

greatest promise of allowing each individual to achieve to the fullest of his desires and capabilities. The present study proposed to make use of an educational setting where individualized instruction was being used exclusively.

Selected modes of instruction were the concern of the second section of this review. Studies comparing the traditional lecture-discussion method and more individualized approaches were reviewed. Inductive and deductive methods were compared as to their effectiveness. Studies using the direct-detailed and directed-discovery methods were reviewed for their techniques employed and findings. The ability to solve problems is a goal of the educational process. Thorndike (1951) suggested that "real problems in the student's life" should be used. The two modes that were selected for this study, direct-detailed and directed-discovery, yield themselves well to minimal student-teacher interaction in the learning situation.

In the final section of this chapter, learning style was defined. It appears that learning style is a significant aspect of an individual's capacity to learn. Various types of learning styles were discussed. The learning style matrix developed by John Banks was presented.

Related research on teaching and learning was reviewed in the last portion of this section. It was concluded that an individual's learning style could be identified, and that it should be an important consideration in attempting to individualize instructional programs. Although research does exist with regard to the use of learning styles in the teaching and learning environment, none was located that paralleled the proposed experimental matching of this study. The works of Bank and Oen, however, yielded valuable information for this study.

Tallmadge and Shearer (1971) asked some serious questions relative to the effectiveness of all learning style research. However, while questioning the effectiveness, they further state that "it does not appear that learning style research should be abandoned." This study is an attempt to continue the research and the next chapter presents the research design, the setting, and the procedures used.

CHAPTER III

DESIGN OF THE EXPERIMENT

Introduction

The many aspects of the experimental design are described in this chapter. It begins with a description of the setting, population, and sampling procedures and is followed by a discussion of the learning style assessment. Included in the section is the description and discussion of the Learning Activities Opinionnaire as used at the Fox Valley Technical Institute. The pilot study, which was completed to aid in the adaptation of this instrument to the population in question, is discussed also. The following section presents a description of the learning tasks and materials used, along with a discussion of the importance of teaching metric measurements to students in U.S. schools now.

The procedures and treatments used in this study are described next. Samples of the instructional materials may be found in the appendices. The description of the experimental matching scheme is followed by a discussion of the statistical treatment in general. The chapter is brought to a close with a discussion of the hypotheses which were presented in Chapter I and a summary of the overall design of the study.

Setting, Population, and Sampling

Setting

The setting for this study was the Capital Area Career Center in Mason, Michigan. The Center is the area vocational center operated by the Ingham Intermediate School District. It provides vocational training for students attending eleven high schools located within Ingham County, with the exception of those attending the City of Lansing Public Schools.

The Center became operational in September of 1972 with a completely modular (learning packets) curriculum. Individual Prescribed Instruction is made possible through the use of a computerized schedule and record-keeping system. The Center has three occupational areas: Business, Health, and Trade & Industry. Supportative areas are: General Learnings, an instructional area for occupationally related reading, mathematics, blueprint reading, measurement, and pre-employment skills; and Student Services, a counseling, work experience, job placement, and records area.

Population

The population used for this study was the set of approximately 850 students who attended the Capital Area Career Center during the 1974-75 school year. About 450 students attended the morning session and the remaining 400 attended during the afternoon session.

Each student, upon initial enrollment at the Center, had completed a series of tests to ascertain his/her reading and computational skills. The Gates-MacGinitte Reading Tests were used for the assessment of reading skills. An in-house developed mathematics test was used for the assessment of computational skills. The scores of these two tests become a part of the student's record and are used to determine the extent of General Learnings instruction which the student will receive at the Center.

Sampling

The General Learnings Coordinator was asked to randomly select 100 students from all of the occupational programs to participate in this study. Due to program conflicts and absences, the sample for the study consisted of fifty-two morning session students and forty afternoon session students. These ninety-two students represented seventeen out of the twenty-two occupational programs offered at the Center.

From the Business Occupational Area, twenty-five students were chosen, representing such programs as Secretary and Clerical, Bookkeeping and Accounting, Data Processing, Business Services, and Graphics-Visual Communications. Twenty-three students were chosen from the Health Occupational Area, including students from the Histological Technician, Medical Assistant, Dietetic Technician, and Cosmetology programs. The remaining forty-four students came from the Trade & Industry Occupational Area, where the occupational programs of Heating-Air Conditioning, Welding, Building Maintenance, Major Appliance Repair, Electronics Technician, Television Repair, Auto Body, and Machine & Tool are offered.

Table 2 shows the distribution of the student body at the Center in the three occupational areas during the 1974-75 school year.

Also indicated is the number and percentage of the sample from each occupational area. Of the ninety-two students within the sample, thirty-nine were female and fifty-three were male.

Table 2.--Occupational area, population and sample size.

Occupational Area	Student Population	Sample Size	
		Number	%
Business	259	25	9.6
Health	152	23	15.1
Trade & Industry	421	44	10.5
Total	832	92	11.1

Reading comprehension.--The reading comprehension level range, means, and standard deviations for each occupational area represented in the sample are shown in Table 3. It is evident from this table that most of the students had a reading comprehension level above the sixth grade. The sixth grade equivalent reading level is used for all curricular reading material developed and used at the Center. The instrument and instructional materials used in this study were written at the sixth grade equivalent reading level, as indicated elsewhere in this chapter.

Computational skill.--The Computational Skills Test is an instrument which was developed by the General Learnings Area staff and based upon a series of supportative arithmetic manuals produced by Science Research Associates of Palo Alto, California. It consists of a series of mathematical problems dealing with whole number, fractional number, money, and decimal number concepts, and the operations of addition, subtraction, multiplication, and division.

Table 3.--Occupational area and reading comprehension.

Occupational Area (Sample Size)	Reading Comprehension Level[a]		
	Range	Mean	Std. Deviation
Business (25)	7.1-13.5	10.3	1.8
Health (23)	7.1-12.6	9.6	1.4
Trade & Industry (44)	4.5-16.8	10.0	2.9
Overall (92)	4.5-16.8	9.9	2.3

[a]As measured by the Gates-MacGinitte Reading Test, and listed as a grade equivalent score.

The student's tests are scored on a pass-fail basis for each of the operations with each of the concepts. Because of the nature of the mathematics involved in the learning exercises used in this study, only the scores on whole number and decimal number operations were used for the computational skill variables.

Table 4 shows the percentages of pass on whole and decimal number operation by occupational area, for the students in the sample only.

It was indicated earlier that the Reading Comprehension and the Computational Skill Tests are administered upon the student's entry to the Center. Since the study was conducted during the spring term, some time had elapsed since the test scores were collected. It is the policy of the Center to schedule students into the Reading and/or Mathematics Programs of the General Learnings Area if their tests showed that they possessed skills below those required by their particular occupational program. Thus it is quite possible that a number of the students in this study sample actually had higher reading and/or computational levels than are indicated on their records due to instruction received during the school year. The Reading Program attempts to raise the reading skill level to the sixth grade equivalent level, of only those students who scored below this level. Only five students, or 5.4 percent of the sample, were tested below this point. The Mathematics Program has many more students scheduled to it, since, in many of the occupational programs, computational skill is important. Thus it can be assumed that many of the students in this sample had been scheduled for, and had completed, supportative mathematics programs during the school year.

Table 4.--Occupational area and computational skill.

Occupational Area (Sample Size)	Computational Skill	
	Whole Number Operations	Decimal Number Operations
Business (25)	87.5% pass	66.7% pass
Health (23)	79.1% pass	25.0% pass
Trade & Industry (44)	77.3% pass	40.9% pass
Overall (92)	80.4% pass	43.5% pass

It should be pointed out that thirty-seven students in the sample, or 40.2 percent, had passed both the whole number and the decimal number portions of the Computational Skills Test. These students, therefore, would not have received additional instruction in whole number or decimal number skills.

The computational skills of the remaining fifty-five students may have improved, indeed, would be expected to have improved, from the level shown at time of entry to the Center. However, prior end-of-school-year retests on the Computational Skills Test (on a random number of students) have shown that the computational skill improvement was not as great as would be expected from the amount of exposure to the supportative mathematics program.

It was therefore concluded that the scores on the Reading Comprehension Level and the Computational Skills Tests are reasonably accurate indicators of the abilities of the students in this sample for the purposes of this study. It was therefore decided not to retest the students on these measures.

Learning Style Assessment

Background

Many individualized instructional programs have spent considerable research time and monies deciding on the content of the curriculum. In many of these programs, emphasis seems to be placed upon the time required for the student to complete the program. However, little is ever indicated that the individual learner and his needs were of concern to the developers.

As James Dunn stated in a paper he delivered at an American Psychological Association Symposium:

> If one is to be serious about the individualization, however, in addition to individualization based on _what_ is to be learned, and individualization based on _amount of exposure_ to that which is to be learned, individualization must also be based on _how_ one will learn, i.e., on learning style, on the various ways in which the content to be learned may be studied.[1]

Dunn continues by stating that it is necessary to have information about the needs, interests, abilities, and aspirations of the individual for whom the program of study is to be generated.[2]

This is where the assessment of the students' learning style becomes of importance. As was indicated in the review of literature, it is possible to assess learning style. However, the instruments that are available vary considerably in purpose, complexity of administration, scoring, and interpretation.

Learning Activities Opinionnaire

A meeting with Urban Oen led this researcher to look at the learning styles project Oen was directing at Fox Valley Technical Institute. Oen's interests were multidimensional, and included among other items: (1) the identification of learning styles relevant to vocational-technical education, (2) the development of an ideal

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[1] James A. Dunn, "The Accommodation of Individual Differences in the Development of Personal Programs of Study," in _Developmental Efforts in Individualized Learning_, ed. Robert A. Weisgerber (Itasca, Illinois: F. E. Peacock Publishers, Inc., 1971), p. 31.

[2] Ibid., pp. 31-32.

individualized learning model, and (3) the development of a computer-based management system.[3]

A part of this learning styles project was subcontracted by the University of Wisconsin-Stout with John Banks as its director. Banks' responsibility was to develop a learning styles attitude instrument which would be used to assess students' learning styles.[4]

The final instrument, "Learning Activities Opinionnaire" (see Appendix B), measured the students' learning styles on two continua: (a) concrete-symbolic, and (b) structured-unstructured. The concrete-symbolic continuum is characterized by preference for direct, personal, and hands-on activities using tools and materials; to preference for dealing with abstract representations of objects and phenomena to convey learning. The structured-unstructured continuum is characterized by preference for highly organized activities with passive student involvement in planning; to preference for self-pacing and active student involvement in planning and organizing.

The Learning Activities Opinionnaire contains twenty-two items which reflect various points on the two continua (concrete/symbolic and structured/unstructured). Scoring was done in such a manner that high scores represent the concrete and structured learning

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[3]Urban T. Oen, "Investigating the Interaction of Learning Styles and Types of Learning Experiences in Vocational-Technical Education," Interim Report (Appleton, Wisconsin: Fox Valley Technical Institute, August 1973).

[4]John C. Banks, "An Investigation of the Interaction of Learning Styles and Types of Learning Experiences in Vocational-Technical Education," Final Report (Menomonie, Wisconsin: Center for Vocational, Technical and Adult Education, University of Wisconsin-Stout, June 1973).

styles. The first eleven items on the instrument relate to the concrete/symbolic learning style. The high score of fifty-five on these items would indicate a very concrete learning style, while a low score of eleven would reflect a very symbolic learning style. The last eleven items are concerned with the structured/unstructured learning style, and are scored in a similar manner.

Perusal of the reports written by Oen and Banks led the researcher to decide that the instrument which they had used might well fit the intent of the present study. John Banks granted permission to use and/or adapt the Learning Activities Opinionnaire for this study.

Pilot Test

It was decided that a pilot testing of the Learning Styles Opinionnaire should be undertaken with a sample of secondary school students. The readability of the instrument was of major concern since the average age of the population of this study was younger than that used by Banks.

The Area-Wide Career Opportunities Program, operated by the Eaton Intermediate School District, Charlotte, Michigan, serves a population which is similar to that of the Capital Area Career Center. Permission was granted to administer the Learning Styles Opinionnaire as a pilot test to two groups of their students--those in the Nurse Aide and those in the Electricity-Electronics classes. These students were able to identify eight items which they found difficult to comprehend.

The distribution of scores for the pilot test of Banks' Learning Activities Opinionnaire is shown in Figures 2 and 3. Figure 2 shows the distribution of scores for the sixteen students in the Electricity-Electronics class. The distribution of scores for the twelve students in the Nurse Aide class is shown in Figure 3.

The eight items that were found difficult to comprehend by the secondary school students from the Area-Wide Career Opportunities program were rewritten. The SMOG grading technique was then applied to the revised instrument, to test it for readability at the sixth grade equivalent level. Several other items of the instrument were consequently rewritten--as well as the "Instructions to the Student," which prefaces the instrument. The modified instrument was renamed at this time--"Learning Activities Survey"--and may be found in Appendix C of this study.

The Learning Task

Description of Materials

The materials which comprise the learning task of this study are in two parts. The first part deals with learning materials related to the common prefixes and basic units of the metric system. The second contains learning materials that teach conversion between the metric and the customary (English) systems of measurement (see Appendix A for these materials and related tests).

More specifically, the metric learning materials contained a discussion of the decimal relationship of the common prefixes and the quantities of length, mass or weight, and volume. Example problems

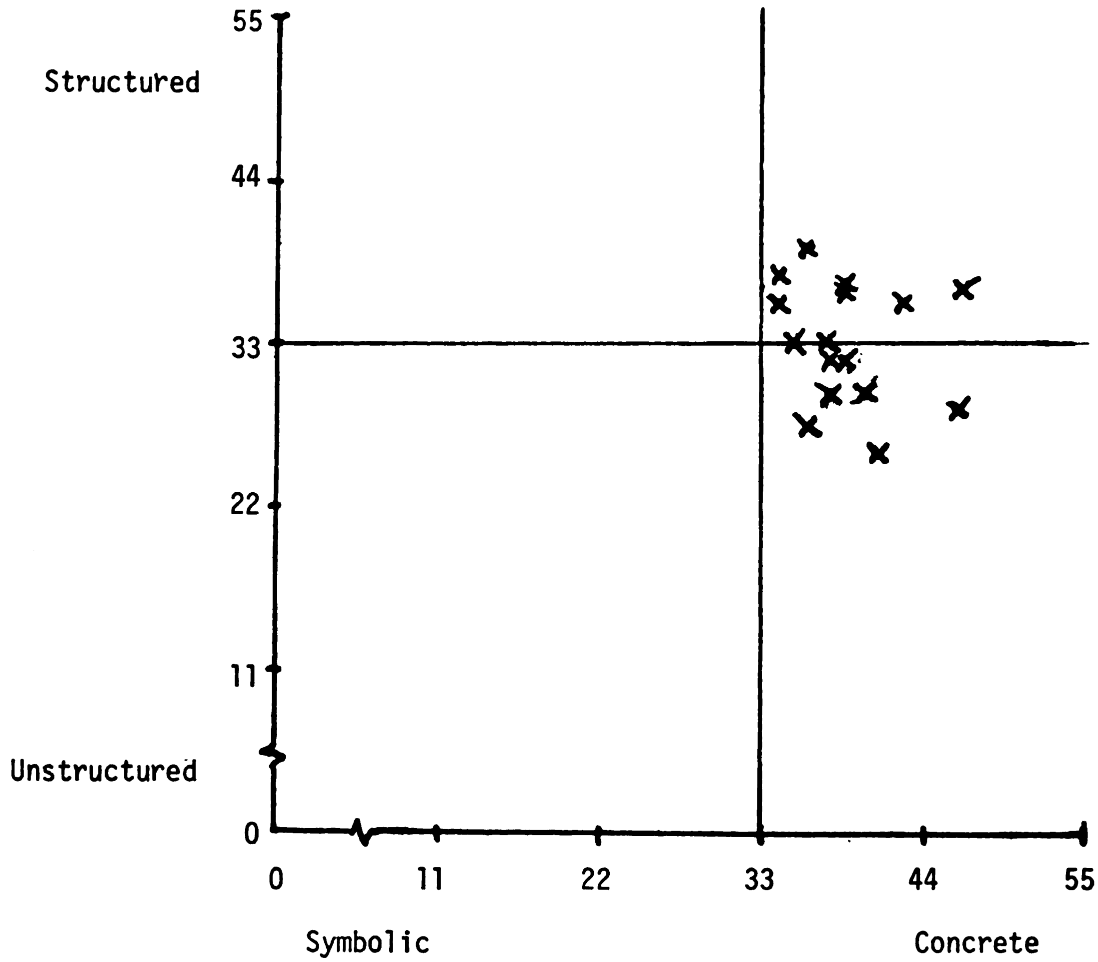

Fig. 2.--Distribution of scores on the Learning Activities Opinionnaire; pilot administration, Electricity-Electronics class.

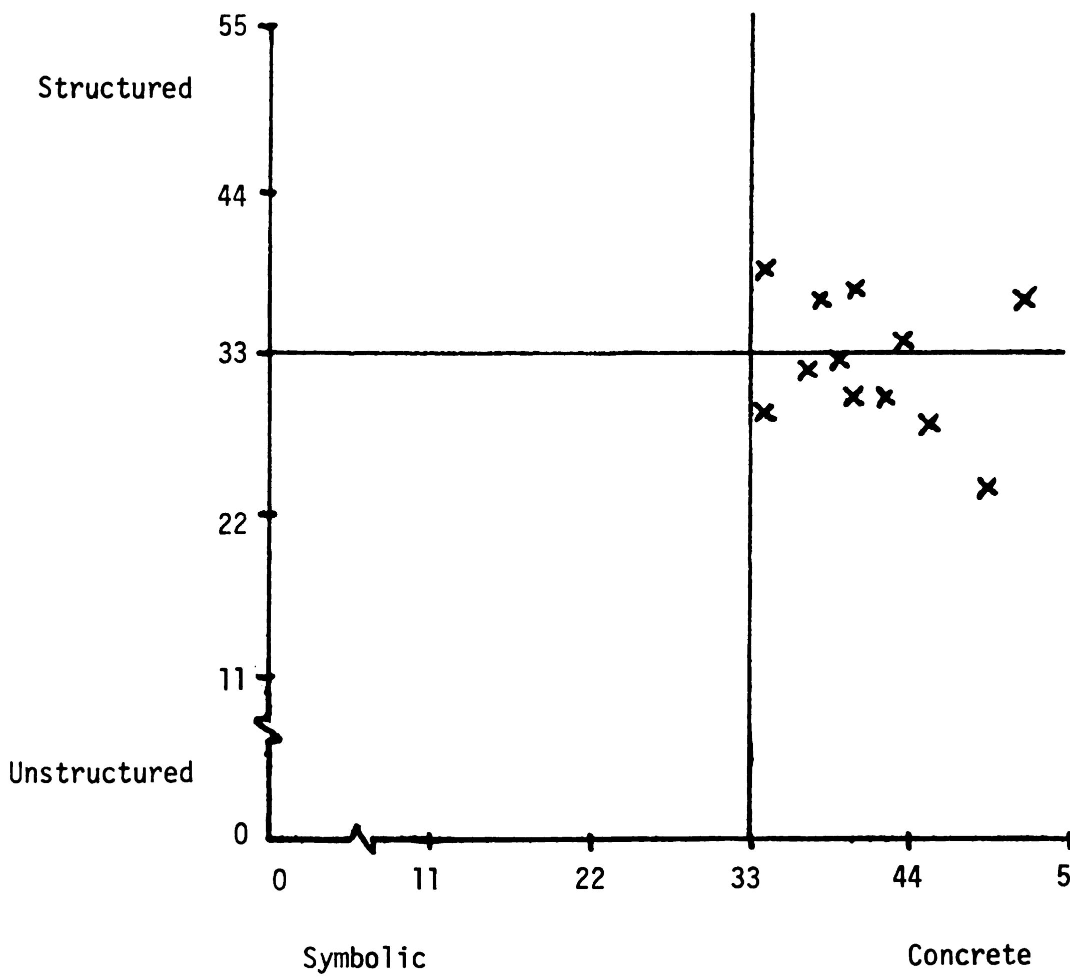

Fig. 3.--Distribution of scores on the Learning Activities Opinionnaire; pilot administration, Nurse Aide class.

in each were posed, and either completed (in the case of structured learning), or hints given on how to complete them (in the case of unstructured learning). Finally, a series of problems was given for exercises.

The learning materials for the conversion between the metric and customary (English) systems followed a similar pattern. In addition, these materials suggested a simple, and perhaps novel, method for accomplishing the conversions. The method uses either multiplication or division by a constant factor for each quantity of measurement (length, mass, and volume) depending upon the direction of the desired conversion. The advantages of this method are: (1) it is simple to learn, (2) the same procedure is used with all quantities, and (3) at the time of complete adoption of the metric system, one need have learned only a few conversion factors.

Rationale for Their Use

The choice of the metric system materials for this learning task was based on several conditions that exist at the present time:

1. Newness of the material for the student. In a survey conducted for the U.S. Metric Study, the Survey Research Center of the University of Michigan found that the general public knows little about the metric system. Only 40 percent could name a single unit, and only half of those were familiar with relationships between metric and customary units.[5]

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[5]Daniel V. DeSimone, A Metric America, Special Publication 345 (Washington, D.C.: U.S. Department of Commerce, National Bureau of Standards, July 1971), p. 79.

Among respondents aged less than 25 years, 33 percent knew little or nothing, 43 percent knew something, and only 24 percent knew a great deal about the metric system. In contrast, when one compares on the basis of education, one finds that of those respondents who have completed 11 grades or less: 82 percent knew little or nothing, 15 percent knew some, and only 3 percent knew a great deal about the metric system.[6]

The students who attend the Capital Area Career Center are part of the population from which the Survey Research Center of the University of Michigan selected its sample for the above statistics. It was assumed, therefore, that a random sample of these students would show similar statistics.

A discussion held with the Center's staff, concerning the curriculum content of the various programs, revealed that only one program (Histologic Technician) used the metric system of measurement. However, no instruction is given in this program on the conversion between the metric and customary systems. Of the ninety-two students in this study, only three were from the Histologic Technician program. Thus, only this 3 percent of the sample could be assumed to be somewhat familiar with the metric system materials as a direct result of instruction at the Center.

On the basis of these data, it was concluded that pretesting of the students on their knowledge of the metric system and conversion between the metric and customary systems of measurement was not necessary.

2. Change to the use of the metric system in the United States is now inevitable. Although the Congress has many times in

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[6]Ibid., p. 80.

the last two centuries considered the merits of adopting the metric system, each time action was postponed. The primary reason for non-adoption was that the foreign trading partners of the U.S. were not themselves using the metric system. Today, however, all other major nations either have converted, or are committed to conversion to the metric system.

In 1968, the Secretary of Commerce was authorized by Congress "to make a study to determine advantages and disadvantages of increased use of the metric system in the United States."[7] This study, undertaken by the National Bureau of Standards, recommended two major actions that should be begun immediately:

> A. The first is education. Every school child should have the opportunity to become as conversant with the metric system as he is with our present measurement system.
> B. The second concerns international standards. High quality American industrial practices should be much more vigorously promoted in international negotiations that are beginning to establish "engineering standards" on a worldwide basis and will increasingly affect world trade.[8]

The Secretary of Commerce, in transmitting the report on the U.S. Metric Study to the U.S. Congress, recommended

> A. That the Congress . . . establish a target date ten years ahead, by which time the U.S. will have become predominantly, though not exclusively, metric; and
> B. that early priority be given to educating every American schoolchild and the public at large to think in metric terms.[9]

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[7]Public Law 90-472, approved August 9, 1968, by the Congress of the United States of America.

[8]DeSimone, <u>A Metric America</u>, p. xvi.

[9]Maurice H. Stans, Secretary of Commerce, from a cover letter submitted with the U.S. Metric Study Report to the Congress of the United States of America (Washington, D.C., 1971).

It was therefore concluded to be a propitious time to use the learning materials on the metric system and conversion between the metric and customary systems for this study. This particular set of supportative materials provided a learning situation which fulfilled the following criteria for the selection of a task:

1. It is concerned with a new system of measurement that the student will find increasingly in use in the schools, in industry, and in everyday life;
2. there exists a need for such instruction;
3. performance can be evaluated objectively and accurately; and
4. the teaching-learning process could be accomplished in a relatively short period of time.

Procedures and Treatments

During the 1974-75 school year, a total of 832 students attended the Capital Area Career Center. Ninety-two, or 11.1 percent, were randomly chosen by the General Learnings Coordinator to participate in this study. These ninety-two students make up the sample, with a sex-distribution of fifty-three males (58 percent) and thirty-nine females (42 percent).

All subjects received the same verbal introduction to the purpose of the study and instructions on the procedures to be followed. The "Learning Activities Survey" was administered, and, as the students completed this instrument, they were randomly assigned to either Treatment A or Treatment B. Random assignment was achieved by a toss of a coin. This yielded forty-seven students assigned to

Treatment A and the other forty-five students assigned to Treatment B. One student was found who could not comprehend the materials. This student was excused from participating in the study during the administration of the Learning Activities Survey.

The appropriate form of the learning material, Instructional Materials (Form A or B), was then given to the student. The student was allowed to study the first learning packet, or module, for as long as desired. A ten-item performance test was administered upon completion of the study time. The learning materials for the second module (of the same treatment form as the first) was exchanged for the completed test. When the student finished the study of the second module, he received a second performance test relating only to the material in the second module. (The reader is referred to Appendix A for the complete set of learning materials and tests.)

The average completion time for both sets of learning materials performance tests was one and one-half hours. The students completed all materials by themselves, with no interaction allowed between fellow-students, and no assistance given by the instructor. The instructor merely served as an administrator of the materials.

Treatment A is similar in format to the instructional materials developed at the Center. These materials, or mods, are a step-by-step set of instructions. They represent a traditional approach to the teaching of skills, often called the "tell and do" method. Treatment B also represents a traditional approach which may be called the "Socratic" method. Given a problem, a set of leading questions is presented to direct the learner to its solution. In order to make these materials parallel to those of Treatment A, they were presented in a similar learning packet format.

Treatment A, the direct-detailed method, used the materials which were developed and called Instructional Materials (Form A). In this learning packet, methods were presented, problems were posed and solved in great detail. Important parts were reviewed, again using the step-by-step technique. At the end of the learning packet, eighteen problems were given and the student was shown exactly how to solve them, using the methods previously described.

Treatment B, the directed-discovery method, used the materials which were developed and called Instructional Materials (Form B). This learning packet presented exactly the same material to be learned; however, the approach was quite different. Following a brief, concise description of the method, the example problems were posed and the student was then encouraged to solve them himself. Hints were interspersed where appropriate, and answers were provided in subsequent sections. These provided "feedback" and reinforcement. At the end of the learning packet, the identical eighteen problems were given; the student was directed to solve them and then check his answers with the instructor.

It should be emphasized that both forms of instructional materials were completely in a reading format. All of the instructional materials, as well as the previously discussed Learning Activities Survey, had been tested with the SMOG grading technique to ensure an equivalency of the sixth grade reading level.

The two performance tests were readministered after a five-week lapse, to test for retention of learning. Due to conflicts in scheduling, a total of fifty-three students (58 percent) were tested for retention. These conflicts resulted from the retests being held at the end of the school year. Consequently, students were found to be absent from the Center due to their (1) taking final examinations at their "home" school, (2) being on a "work-experience" assignment, or (3) having completed their program of study at the Center.

Description of Experimental Matching

The design of the experiment is derived from the matrix shown in Table 5. The levels of the learning styles are derived from each subject's composite score on the Learning Activities Survey. The instrument is discussed in more detail elsewhere in this chapter; however, it should be indicated that measurements are made on two continua: (1) concrete-symbolic and (2) structured-unstructured. Using the midpoint of the continuum as the dividing line, the four levels are generated: (a) concrete-structured, (b) concrete-unstructured, (c) symbolic-unstructured, and (d) symbolic-structured.

Two experimental instruction methods were used as the treatments for the experiment. The direct-detailed method was used as Treatment A, and Treatment B consisted of the directed-discovery method.

The several letter-coded subcategories of the matrix shown in Table 5 are defined as follows:

K = MATCH. The learning style and treatment are in harmony. For example, a concrete-structured level individual should find the instruction given under Treatment A to be his preferred method.

L = NONMATCH. The learning style and treatment are dissonant. For example, a symbolic-unstructured level individual should find the instruction given in Treatment A to be less preferred than that under Treatment B.

Table 5.--Learning styles-treatments matrix.

Level of Learning Style	Treatment	
	A--Direct-Detailed	B--Directed-Discovery
Concrete-structured	K	L
Concrete-unstructured	M	N
Symbolic-unstructured	L	K
Symbolic-structured	N	M

There exists the possibility that the individual may score above the midpoint on one continuum and below the midpoint on the other continuum of the Learning Activities Survey. This yields the two letter-coded subcategories on the matrix (Table 5), which are defined as follows:

M = MISMATCH 1. The first part of the level (concrete or symbolic) is in harmony with the treatment. For example, a concrete-unstructured level individual should find his "concrete" mode in agreement with the format of Treatment A. Likewise, a symbolic-structured level individual should find his "symbolic" mode in agreement with the format of Treatment B.

N = MISMATCH 2. The first part of the level (concrete or symbolic) is dissonant with the treatment. For example, a symbolic-structured level individual should find his "symbolic" mode in disagreement with the method used in Treatment A. Similarly, a concrete-unstructured level individual should find that his "concrete" mode disagrees with the method of Treatment B.

The type of match and distribution of subjects by treatments and totals is shown in Table 6. This distribution is the result of the subjects' scores on the instrument and the random assignment to the treatments.

Table 6.--Distribution of subjects by type of match, treatment, and totals.

Type of Match	Treatment		Total
	A	B	
Match (K)	25	3	28
Nonmatch (L)	3	24	27
Mismatch 1 (M)	16	4	20
Mismatch 2 (N)	3	14	17
Total	47	45	92

The original proposed design for the experiment was of the level-by-treatment format. However, the distribution that resulted from the random assignment to the treatments, and the cautions posed by educational researchers (see Statistical Treatments--General, later in this chapter) regarding trait-treatment interaction studies, redirected the design of this experiment.

The final design of this experiment is presented in Table 7. The distribution of subjects is shown, referenced to the level of match and the two sets of measurements relating to learning. The total number of subjects in the retention column is decreased due to conflicts in scheduling the students for the Retention Test. Percentages shown in parentheses are based upon retention cell size compared with initial cell size.

Table 7.--Distribution of subjects by level of match and number of students.

Level of Match	Number of Students Tested		
	Initial Learning	Retention	(Percent)[a]
Match (K)	28	11	(39%)
Nonmatch (L)	27	18	(67%)
Mismatch 1 (M)	20	15	(75%)
Mismatch 2 (N)	17	9	(53%)
Total	92	53	(58%)

[a]Percent = (Retention/Initial Learning) x 100.

The statistical techniques of regression analysis and multivariate analysis of variance were applied to the collected data for comparison of the levels of match with regard to initial learning and retention.

The independent variables were: (a) methods of instruction and (b) learning style. The dependent variables were: (a) initial learning as measured immediately following treatment and (b) retention as measured five weeks after instruction. The controlled variables included: (a) content and method of presentation under both Treatments A and B, (b) the length of instruction, (c) the total time allotted to learning, and (d) tests and testing conditions.

Statistical Treatment--General

The basic design of this experiment, that is, levels by treatments, would have lent itself well to the treatment of analysis of variance (ANOVA). However, the primary interest of the experimenter was to determine whether or not the individual could be aided by being matched with his or her best method of instruction. This precluded the use of the ANOVA technique exclusively, since ANOVA primarily shows the best treatment for the group as a whole. That some students may do better with one mode of instruction, while other students do better with a second mode, would be disguised by the use of a measure of central tendency such as ANOVA.

Berliner and Cohen caution the educator in using research or instruction relating to this area of Treat-Treatment Interaction, or TTI. They write that research involving the use of TTI

> . . . would compel the educator to consider simultaneously traits, aptitudes, attributes or characteristics that the learner brings to the situation; the characteristics and dimensions of the instructional agent or medium of instruction; the content to be learned; and the environment in which the instruction takes place.[10]

The intent of this study was to consider the individual and his uniqueness, as he finds himself in a learning environment. The "Learning Activities Survey" was used to assess the individual's preferred learning style. The two instructional modes used as treatments in this experiment were developed to supply alternate instructional formats, and allow for the control of the content and setting.

Cronbach and Snow have argued for the use of regression models rather than the use of analysis of variance with trait-treatment interaction studies. They hold the first as a more efficient approach for detecting interactions from data obtained in TTI. Regression analysis has the advantage of: (a) tending to decrease the error component, (b) allowing the use of categorical information, (c) creating interaction terms through the use of cross-products, and (d) allowing these interaction terms to be tested in the analysis model.[11]

As this study is of the trait-treatment interaction type, and considering the purpose of the study and nature of the collected data, the use of regression analysis as the main statistical technique

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[10] David C. Berliner and Leonard S. Cohen, "Trait-Treatment Interaction and Learning," in Review of Research in Education, ed. Fred N. Kerlinger (Itasca, Illinois: F. E. Peacock Publishing, Inc., 1973), p. 59.

[11] Lee J. Cronbach and R. E. Snow, Individual Differences in Learning Ability as a Function of Instructional Variables, Final Report (Palo Alto: Stanford University, School of Education, 1969).

was therefore considered appropriate. The general regression analysis equation used in the statistical analysis is:

$$Y = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \cdots$$

where the X's are the factors for consideration. Cross-products were formed to test for the presence of interaction among these factors. For the purposes of this study, the 0.05 level of significance for testing hypotheses was used. The data analysis was performed on the Michigan State University CDC 6500 computer, using the modified Finn multivariance program.[12]

Hypotheses

One of the intended purposes of this study was to provide experimental research evidence of the effectiveness of matching the learning style of the student with the instructional modes selected The general hypotheses for consideration were:

Hypothesis 1: There is no significant difference in initial learning (knowledge of specific facts and principles and ability to solve problems) between students with a learning style when matched to an instructional mode, and students whose learning style does not match the instructional mode.

Hypothesis 2: There is no significant difference in retention of material initially learned as measured five weeks after instruction between students with a learning style when matched to an instructional mode and students whose learning style does not match the instructional mode.

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[12]Jeremy D. Finn, A Generalized Univariate and Multivariate Analysis of Variance, Covariance, and Regression Program (Buffalo: State University of New York at Buffalo, Department of Educational Psychology, 1968).

Hypothesis 3: There is no interaction between the two instructional modes employed and the student characteristics of sex, age, reading comprehension level, and computational skill with regard to initial learning and retention.

The types of match and distribution of subjects are discussed in detail in the description of experimental matching section of this chapter. The specific hypotheses considered in this study are derived from the Learning Styles-Treatments Matrix shown earlier in Table 5 and repeated for convenience below.

Learning Styles-Treatments Matrix

Level of Learning Style	Treatment	
	(A) Direct-Detailed	(B) Directed-Discovery
Concrete-structured	K	L
Concrete-unstructured	M	N
Symbolic-unstructured	L	K
Symbolic-structured	N	M

The specific hypotheses for consideration in the statistical analysis were:

1. There is no significant difference in initial learning between matched group K and nonmatched group L.

2. There is no significant difference in initial learning between mismatched group M and mismatched group N.

3. There is no significant difference in retention of material initially learned, as measured five weeks after instruction, between matched group K and nonmatched group L.

4. There is no significant difference in retention of material initially learned, as measured five weeks after instruction, between mismatched group M and mismatched group N.

The four additional variables that were examined for possible interaction with the main effect--(1) sex of the student, (2) age of the student, (3) reading comprehension level of the student, and (4) computational skill of the student--yield the following subcategory hypotheses in regard to interaction:

5(a) There is no interaction between the two instructional modes employed and the student characteristic of <u>sex</u> with regard to initial learning and retention.

5(b) There is no interaction between the two instructional modes employed and the student characteristic of <u>age</u> with regard to initial learning and retention.

5(c) There is no interaction between the two instructional modes employed and the student characteristic of <u>reading comprehension level</u> with regard to initial learning and retention.

5(d) There is no interaction between the two instructional modes employed and the student characteristic of <u>computational skill</u> with regard to initial learning and retention.

Summary

The format of the experiment was described in this chapter. Students at the Capital Area Career Center in Mason, Michigan, served as the population for the study. Ninety-two students, from seventeen of the twenty-two occupational programs, were randomly chosen as the subjects to participate in the experiment. Data on the student characteristics of sex, age, reading comprehension level, and computational skill were obtained from records at the Center.

To adapt the selected learning style instrument to the population of the study, a pilot study was completed using a similar group of secondary vocational students in another setting. The revised learning activities survey was to be used at the Center to assess the learning style preferences of the students in the sample of this study.

The content of the instructional material was derived from the metric and customary (or English) systems of measurement. The choice of this material was based on the newness of the material and the inevitable need to know as the United States is moving in the direction of accepting the metric system as the standard and common system of measurement. The instructional materials were developed into two sets of learning packets, and represent the two selected modes of instruction. Direct-detailed (Treatment A) is similar in format to the instructional materials in use at the Center, while the directed-discovery (Treatment B) format was developed as an alternative approach.

The design of the experimental matching between learning style and instructional mode was described using a matrix technique. The four levels of matching were discussed along with the distribution of subjects.

The proposed statistical techniques of regression analysis and multivariate analysis of variance were presented. Five specific hypotheses to be considered were presented relative to the levels of matching and the selected student characteristics.

The next chapter describes the data collected on the learning style assessment, and the analysis of the learning data. A discussion of the statistical analysis is also presented.

CHAPTER IV

RESULTS OF THE EXPERIMENT

This chapter is divided into two major sections, each relating to an objective of the study. The learning style assessment of the students at the Capital Area Career Center is discussed in the first section. A series of figures graphically illustrates the assessed learning styles. These figures may be used to interpret the preferred learning styles within each occupational area at the Center.

The second section considers the analysis of the collected learning data in relation to the experimental matching of learning style with instructional mode. The hypotheses are discussed on the basis of the results of the analysis.

Learning Style Assessment

One of the goals of this study was to identify the learning styles of the students. This was accomplished through the use of the Learning Activities Survey (see Appendix C). The learning styles of students in the Business, Health, and Trade & Industry occupational areas were measured.

The study sample consisted of ninety-two students, or 11.1 percent of the total population of 832. These were randomly selected to participate in the study during the spring semester, 1975. Table 8 shows the distribution of students by occupational area, sex, time of day of attendance at the CACC, and totals. From the Business Occupational Area programs, twenty-five students, or 10.0 percent of the total enrolled in that area, were selected. The Health Occupational Area programs were represented by twenty-three students, 15.1 percent of those enrolled in that area, while from the Trade & Industry Occupational Area programs forty-four students, or 10.5 percent of enrollment, were selected.

Table 8.--Distribution of students by occupational area, sex, and time of day of attendance.

Occupational Area	Female		Male		Total
	AM	PM	AM	PM	
Business	9	8	5	3	25
Health	13	8	2	0	23
Trade & Industry	1	1	22	20	44
Total	39		53		92

Concrete/Symbolic

Concrete/symbolic instrument.--The first eleven items on the Learning Activities Survey measure the learning style continuum defined as concrete at one pole and symbolic at the other pole. Items 1-6 contain statements relating to "hands-on" or direct contact with the phenomena or experiences used in the learning environment. These items measure the concrete dimension.

Items 7-11 contain statements relating to oral, reading, or computational experiences found in the learning environment. Thus, these items measure the symbolic dimension.

Scoring was accomplished by assigning values of 1-2-3-4-5 to the response categories of "Of No Value," "Of Little Value," "Of Average Value," "Very Valuable," and "Extremely Valuable" for the first six items. For the remaining five items, the reverse values of 5-4-3-2-1 were assigned to the same response categories. A highly concrete individual, attaining a maximum score of fifty-five, would have accepted items 1-6 at the "Extremely Valuable" level and would have rejected items 7-11 at the "Of No Value" level. Within the total group tested in this experiment, the highest score achieved by a student was fifty. In similar fashion, a highly symbolic individual, with a minimum score of eleven, would have replied to the eleven items in an opposite manner. Within the total group tested in this experiment, the score of twenty-six was the lowest achieved by a student.

An individual's position on the continuum depends upon that person's acceptance or rejection of the value of the type of learning experience defined in each statement of the instrument. Individuals located, therefore, along the continuum, with location toward either end indicating a strong preference for that style. Locating near the midpoint (thirty-three) indicates a desire for a mixture of learning styles.

Frequency distribution.--Figures 4, 5, and 6 provide the reader with a graphic representation of the range measured on the

Concrete	46	
	45	*
	44	
	43	**
	42	***
	41	*
	40	*
	39	*
	38	***
	37	***
	36	*****
	35	
	34	**
	33	----- Concrete/Symbolic Continuum Midpoint
	32	**
	31	
	30	
	29	
	28	
	27	*
Symbolic	26	

N = 25 $\overline{X} = 37.64$

Fig. 4.--Concrete/symbolic continuum showing the frequency distribution of students from the Business Occupational Area at the Capital Area Career Center.

	45		
Concrete	44	*	
	43	*	
	42		
	41	**	
	40	***	
	39	*	N = 23 $\bar{X}$ = 36.57
	38	***	
	37	*	
	36	*	
	35	***	
	34		
	33	**	----- Concrete/Symbolic Continuum Midpoint
	32	***	
	31		
	30	*	
	29	*	
Symbolic	28		

Fig. 5.--Concrete/symbolic continuum showing the frequency distribution of students from the Health Occupational Area at the Capital Area Career Center.

Concrete	51		
	50	*	
	49		
	48		
	47		
	46		
	45		
	44	**	N = 44 $\overline{X}$ = 36.89
	43	**	
	42	*	
	41	****	
	40	*	
	39	*	
	38	*****	
	37	******	
	36	*****	
	35	***	
	34	***	
	33	******	------ Concrete/Symbolic Continuum Midpoint
	32	*	
	31	*	
	30		
	29		
	28	*	
	27		
	26	*	
Symbolic	25		

Fig. 6.--Concrete/symbolic continuum showing the frequency distribution of students from the Trade & Industry Occupational Area at the Capital Area Career Center.

concrete/symbolic continuum by each of the occupational areas. The potential range of scores varies from a value of fifty-five for the highly concrete to a value of eleven for the highly symbolic. Figure 4 shows the frequency distribution for the students from the Business Occupational Area, Figure 5 shows the frequency distribution for the students from the Health Occupational Area, and Figure 6 provides the same information for students from the Trade & Industry Occupational Area.

The midpoint on the scale (thirty-three) is provided by a response average of three. Responding to all eleven statements with the same category would have yielded the following scores: thirty-one for the "Of No Value" category, thirty-two for the "Somewhat Valuable" category, thirty-three for the "Of Average Value" category, thirty-four for the "Very Valuable" category, and thirty-five for the "Extremely Valuable" category. There were no students who responded in this manner, although these numerical values do occur as a result of a mixture of choices among the various categories by the respondents. All of the occupational areas achieved mean scores above the midpoint; thus the groups tend toward the concrete end of the continuum.

The Business Area students achieved a mean score of 37.64 as shown in Figure 4. Only three students (12 percent) of this group scored below the continuum midpoint (thirty-three), while the remaining twenty-two individuals attained scores which ranged from thirty-four to forty-five. This preference for the concrete style fits the type of occupation which these students will enter very well. Most business areas do function within a very concrete work environment.

The students in the Health Occupational Area achieved a mean score of 36.57 as shown in Figure 5. This was the lowest mean score of the three occupational groups tested at the Capital Area Career Center. There were five students (22 percent) of this group who attained scores below the midpoint of the continuum (thirty-three), with the remaining eighteen students achieving scores which ranged from thirty-three to forty-four. This high score of forty-four was also the lowest maximum score achieved by the three groups. It is perhaps not surprising to find students who are training for Health Area occupations expressing a wider range of responses to the statements than the students in the Business Occupational Area, since workers in the health occupations do function in the symbolic mode as a part of their daily routine.

Figure 6 shows the distribution of scores for the students in the Trade & Industry Occupational Area. These students achieved a mean score of 36.89. This score is also above the midpoint of the concrete/symbolic continuum, and indicates a preference for more concrete activities. There were four students (9 percent) of this group who attained scores below the midpoint (thirty-three); the remaining forty individuals attained scores which ranged from thirty-three to fifty. This high score of fifty was the highest score achieved by any student in the three groups tested. Of this group, 91 percent achieved scores which indicated a preference for the concrete mode. This also seems most appropriate, since a high percentage of the work activities in occupations in the area of Trade & Industry are of a "hands-on" nature.

Occupational area comparison.--A visual comparison of the mean scores achieved by students, in each of the occupational area programs, on the concrete/symbolic continuum is presented in Figure 7. The students in all of the occupational areas tended to view themselves as favoring a concrete learning style; that is, a learning style that allows the learner to become personally involved with an object or to come into direct contact with the phenomena.

All three occupational area groups tested at the Capital Area Career Center achieved scores that tended to fall toward the concrete end of the continuum. The Business Occupational Area attained a mean score (37.64) that was higher than the total mean score (37.04) of all groups. The Trade & Industry Occupational Area attained a mean score (36.89) which was just below the total mean score; the Health Occupational Area achieved a mean score that was slightly lower still (36.57). It must be emphasized, however, that each of the occupational areas' mean scores was above the midpoint of the continuum, thus indicating a group preference for the concrete style.

At the end of this section on learning style assessments, the reader is provided with graphs which show the placement of each individual plotted along both continua. The axes of the graphs are formed by the two continua of concrete/symbolic (x-axis) and structured/unstructured (y-axis). Separate figures are provided for each of the three occupational areas.

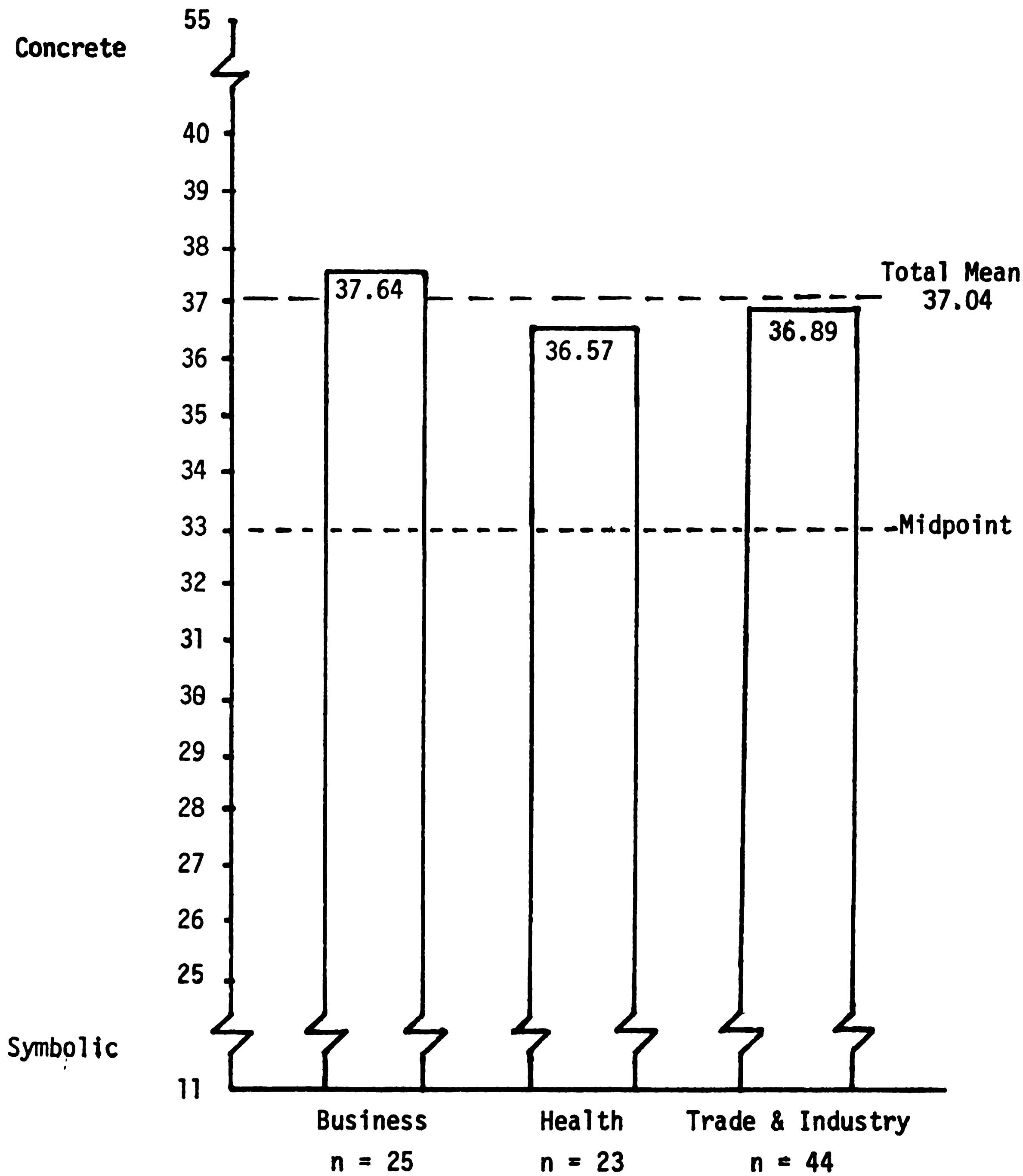


Fig. 7.--Comparison of the mean scores achieved by the three occupational areas on the concrete/symbolic continuum.

Discussion of results on the concrete/symbolic continuum.--The typical style evident within the total group can be determined from the total group mean. A mean above or below the midpoint would indicate a tendency toward the style located at the endpole. A mean near the midpoint would suggest that a mixture of learning styles would be favored. The standard deviations can be used to decide if a range of learning styles exists, and, if they exist, whether they exist to a degree which demands a variety of learning environments or alternate forms of instruction.

The total group, or sample of this study, consisted of ninety-two individuals randomly selected from the three occupational areas. These students achieved a group mean score of 37.04, with a standard deviation of 4.20. The range of scores for the group on the concrete/symbolic continuum was from a low of twenty-six to a high of fifty. Twelve individuals (13 percent of the total group) scored below the midpoint of thirty-three.

The total group mean score of 37.04 is well above the midpoint of the continuum (thirty-three). This would imply that students at the Center tend to favor learning styles which use the concrete mode. However, if one looks at the percentage of students who scored more than one standard deviation above or below the group mean, a slightly different perspective may be gained.

There were fourteen individuals (15.2 percent of the total group) who scored more than 41.24 (one standard deviation above the group mean). This implies that at least 15 percent of the students at the CACC have a highly concrete learning style and would favor learning strategies which employ this style. However, there were also twelve individuals (13.0 percent of the total group) who scored less than 32.84 (one standard deviation below the group mean). The implication here is that at least 13 percent of the CACC's students have a symbolic learning style. These latter students would favor learning strategies employing a symbolic style, or at least favor a mixture of the concrete and symbolic learning strategies in their studies.

Table 9 shows the number of students by occupational area and by total group, who attained scores which were greater than one standard deviation above or below that of the group mean. Both the Business Occupational Area and the Trade & Industry Occupational Area show a preference for the concrete end of the continuum. At least 6 percent of the students in these two groups attained scores which were greater than 41.24, whereas the Health Occupational Area had only 2 percent of their students who attained scores above this point.

In the other direction, there were at least 3 percent of the Business Occupational Area students and 4 percent of the Trade & Industry Occupational Area students who tended toward the symbolic end of the continuum. More than 5 percent of the Health Occupational Area students scored toward the symbolic end of the continuum. It would appear, therefore, that all occupational areas have students who favor symbolic learning strategies.

There are a considerable number of students who attained scores which were between the two extremes shown in Table 9. These should be considered as individuals who would probably do well in learning environments that use a combination of both concrete and symbolic learning strategies.

Table 9.--Number of students by occupational area with scores greater than one standard deviation above or below the total group mean on the concrete/symbolic continuum.

Occupational Area	Number of Students (%)	
	Scores > 41.24	Scores < 32.84
Business	6 (6.5%)	3 (3.3%)
Health	2 (2.1%)	5 (5.4%)
Trade & Industry	6 (6.5%)	4 (4.3%)
Total group	14 (15.2%)	12 (13.0%)

Structured/Unstructured

Structured/unstructured instrument.--The second eleven items on the Learning Activities Survey measure the learning style continuum defined by structured at one pole and unstructured at the opposite pole. Items 12-16 contain statements which relate to the use of preplanned, highly organized experiences in the learning environment, to which the student has little, if any, input. These items, thus, measure the structured dimension. The remaining six items contain statements which relate to the use of student involvement in the planning and organizing of experiences in the learning environment. Thus these items, 17-22, measure the unstructured dimension.

Scoring for this portion of the survey was accomplished by assigning values of 1-2-3-4-5 to the response categories of "Of No Value," "Of Little Value," "Of Average Value," "Very Valuable," and "Extremely Valuable" for the first five items. For the remaining six items, the reverse values of 5-4-3-2-1 were assigned to the same response categories.

An individual's position on the structured/unstructured continuum depends upon that person's acceptance or rejection of the type of learning experiences defined in each statement of the instrument. Individuals located, therefore, along the continuum, with location toward either end indicating a strong preference for that style. Locating near the midpoint (thirty-three) would indicate a desire for a mixture of learning styles.

A highly structured individual would have accepted items 12-16 at the "Extremely Valuable" level and would have rejected items 17-22 at the "Of No Value" level. This would yield a maximum score of fifty-five. There were no students who attained that score. Responding to these items in a completely opposite manner would have produced a minimum score of eleven. This score would indicate a highly unstructured individual and, again, there were no students who attained this minimum score.

<u>Frequency distribution</u>.--A graphic presentation of the range on the structured/unstructured continuum for each of the occupational areas is provided by Figures 8, 9, and 10. The potential range of scores varies from a value of fifty-five for the highly structured

Structured	49		
	48	*	
	47		
	46		
	45		
	44		
	43		
	42	**	
	41	*	
	40		N = 25 $\overline{X}$ = 34.64
	39	*	
	38		
	37	**	
	36	****	
	35	***	
	34	**	
	33	**	------ Structured/Unstructured Continuum Midpoint
	32	***	
	31	*	
	30	***	
	29		
Unstructured	28		

Fig. 8.--Structured/unstructured continuum showing the frequency distribution of students from the Business Occupational Area at the Capital Area Career Center.

Structured	42		
	41	*	
	40	*	
	39		
	38	***	
	37	*	N = 23 $\overline{X}$ = 32.00
	36	**	
	35	**	
	34	*	
	33	***	----- Structured/Unstructured Continuum Midpoint
	32	****	
	31	*	
	30		
	29		
	28	**	
	27		
	26		
	25		
	24		
	23	**	
Unstructured	22		

Fig. 9.--Structured/unstructured continuum showing the frequency distribution of students from the Health Occupational Area at the Capital Area Career Center.

Structured	43		
	42	*	
	41	***	
	40	**	
	39	**	
	38	***	N = 44 $\overline{X}$ = 33.00
	37	*	
	36	**	
	35	**	
	34	****	
	33	***	----- Structured-Unstructured Continuum Midpoint
	32	*****	
	31	***	
	30	*	
	29	**	
	28	*	
	27	*****	
	26	**	
	25		
	24		
	23	*	
	22	*	
Unstructured	21		

Fig. 10.--Structured/unstructured continuum showing the frequency distribution of students from the Trade & Industry Occupational Area at the Capital Area Career Center.

to a value of eleven for the highly unstructured. Figure 8 is a frequency distribution for the students from the Business Occupational Area on the Structured/Unstructured Learning Style Continuum. Figure 9 shows the frequency distribution for the students from the Health Occupational Area and Figure 10 provides similar information for the students from the Trade & Industry Occupational Area.

The midpoint on the scale (thirty-three) was determined by a response average of three. Of the total students (ninety-two) who responded to the instrument, it might be of interest to point out that not one responded to all of the statements in any one column, although some achieved the score of thirty-three.

The students from the Business Occupational Area were the only group who had a mean score (34.64) which was above the midpoint of the continuum. Thus, on the basis of this instrument, these students tend to prefer the structured learning style.

The group had nine individuals (36 percent) who attained scores below the midpoint, while sixteen (64 percent) attained scores ranging from the midpoint to a high score of forty-eight. This high score was also the highest maximum score attained by the three groups.

The Health Occupational Area students obtained the only mean score (32.00) that fell below the midpoint of the continuum. This group, therefore, leans toward the unstructured end of the scale. The frequency distribution of this group shows that there were nine individuals (39 percent of this group) who attained values below the midpoint (thirty-three), with the remaining fourteen students attaining scores which ranged from thirty-three to forty-one.

The students in the Trade & Industry Occupational Area had a mean score (33.00) which fell exactly at the midpoint of the continuum. This group may be thought of, therefore, as desiring a mixture of both structured and unstructured learning strategies. In this group there were twenty-one individuals (47 percent of the group, and the largest group percentage) who attained values below the midpoint. The remaining twenty-three students attained scores which ranged from thirty-three to forty-two.

Occupational area comparison.--Figure 11 provides a visual comparison of the mean scores achieved by students in each occupational area on the structured/unstructured scale. Only the Business Occupational Area tended to view itself as preferring a structured learning style. The Health Occupational Area was the only area that tended to prefer an unstructured learning style, while the Trade & Industry Occupational Area showed a preference for a mixture of both structured and unstructured learning styles.

The mean score of the total group (33.51) is only slightly above the continuum midpoint (thirty-three). The mean score of the Business Occupational Area (34.64) was the only mean score which was above both the midpoint (thirty-three) and the mean score of the total group (33.51). Both the Health Occupational Area mean score (32.00) and the mean score of the Trade & Industry Occupational Area (33.00) were below the mean score of the total group (33.51). The Trade & Industry Occupational Area mean score (33.00) was at the midpoint of the continuum, while the mean score of the Health Occupational

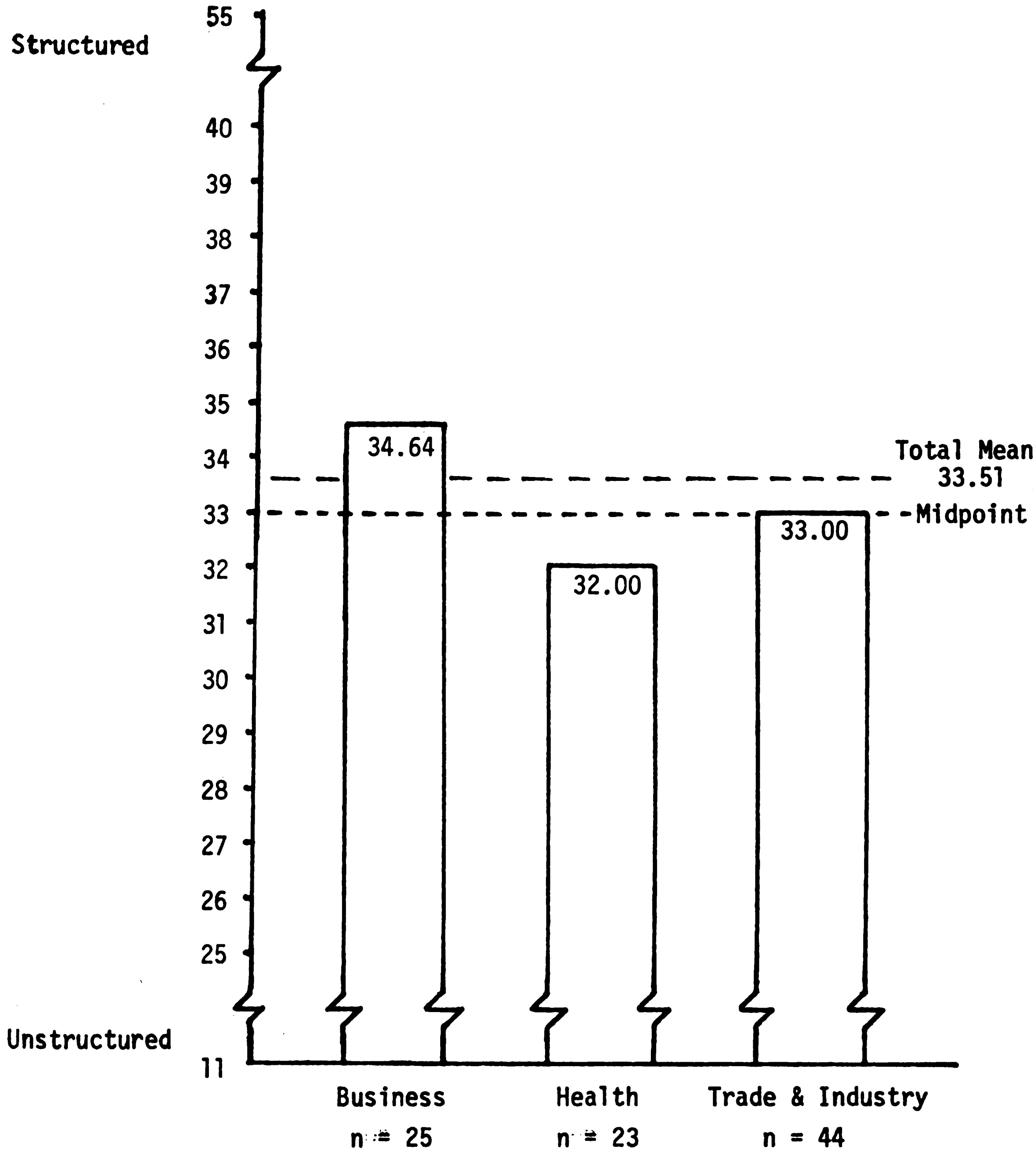


Fig. 11.--Comparison of the mean scores achieved by the three occupational areas on the structured/unstructured continuum.

Area (32.00) was the only score which fell below the midpoint of the structured/unstructured continuum.

Plots of the individual's placement along both continua may be found following the next section. The graphs are formed by the concrete/symbolic continuum as the X-axis and the structured/unstructured continuum as the Y-axis. Separate figures are shown for the Business, Health, and Trade & Industry Occupational Areas, and for the total group.

<u>Discussion of results on the structured/unstructured continuum</u>.--The typical style evident within the total group can be determined from the mean of the total group. A mean score above or below the midpoint would indicate a tendency toward the style indicated at the end pole. A mean near the midpoint would suggest that a mixture of learning strategies would be favored. The standard deviation may be used to decide whether a range of learning styles exists to a sufficient degree to demand a variety of learning strategies. The ninety-two individuals who comprised the sample for this study achieved a mean score of 33.51, with a standard deviation of 4.95. This mean score (of the total group) is very near the midpoint (thirty-three) of the structured/unstructured continuum and would indicate that a mixture of learning strategies is desired by the group.

It should be fair to say that individuals who attained a score greater than 38.46 (one standard deviation above the group mean) would prefer a structured learning strategy. There were fifteen individuals (16.3 percent of the total group) who scored above this point. Likewise, it should be fair to state that individuals who attained a score less than 28.56 (one standard deviation below the group mean) would prefer an unstructured learning strategy. Of the total group of ninety-two students, there were fourteen individuals (15.2 percent) who attained scores which were below this point.

It is evident, therefore, that within this randomly selected sample of students who attend the Capital Area Career Center there are preferences for structured, unstructured, and a mixture of learning strategies.

Table 10 shows the number of students by occupational area and total group who attained scores which were one standard deviation or more above or below the group mean. The Business Occupational Area showed the strongest preference for the structured style. More than 20 percent of the students in this group attained scores which were above 38.46 (one standard deviation above the total group mean). The Trade & Industry Occupational Area had more than 18 percent of its students who scored above this point, while only about 9 percent of the Health Occupational Area students scored above the total group mean.

In the opposite direction, it is evident that no students from the Business Occupational Area scored below 28.56 (one standard deviation below the total group mean). Students in both the Health and the Trade & Industry Occupational Areas, however, showed a preference for the unstructured end of the continuum. More than 17 percent of the Health Occupational Area students and almost 23 percent of the Trade & Industry Occupational Area students attained scores below 28.56. It would appear that these two latter occupational areas have students who strongly favor an unstructured learning environment.

Table 10.--Number of students by occupational area with scores greater than one standard deviation above or below the total group mean on the structured/unstructured continuum.

Occupational Area	Number of Students (%)	
	Scores > 38.46	Scores < 28.56
Business	5 (20.0%)	0 (0.0%)
Health	2 (8.6%)	4 (17.4%)
Trade & Industry	8 (18.2%)	10 (22.7%)
Total group	15 (16.3%)	14 (15.2%)

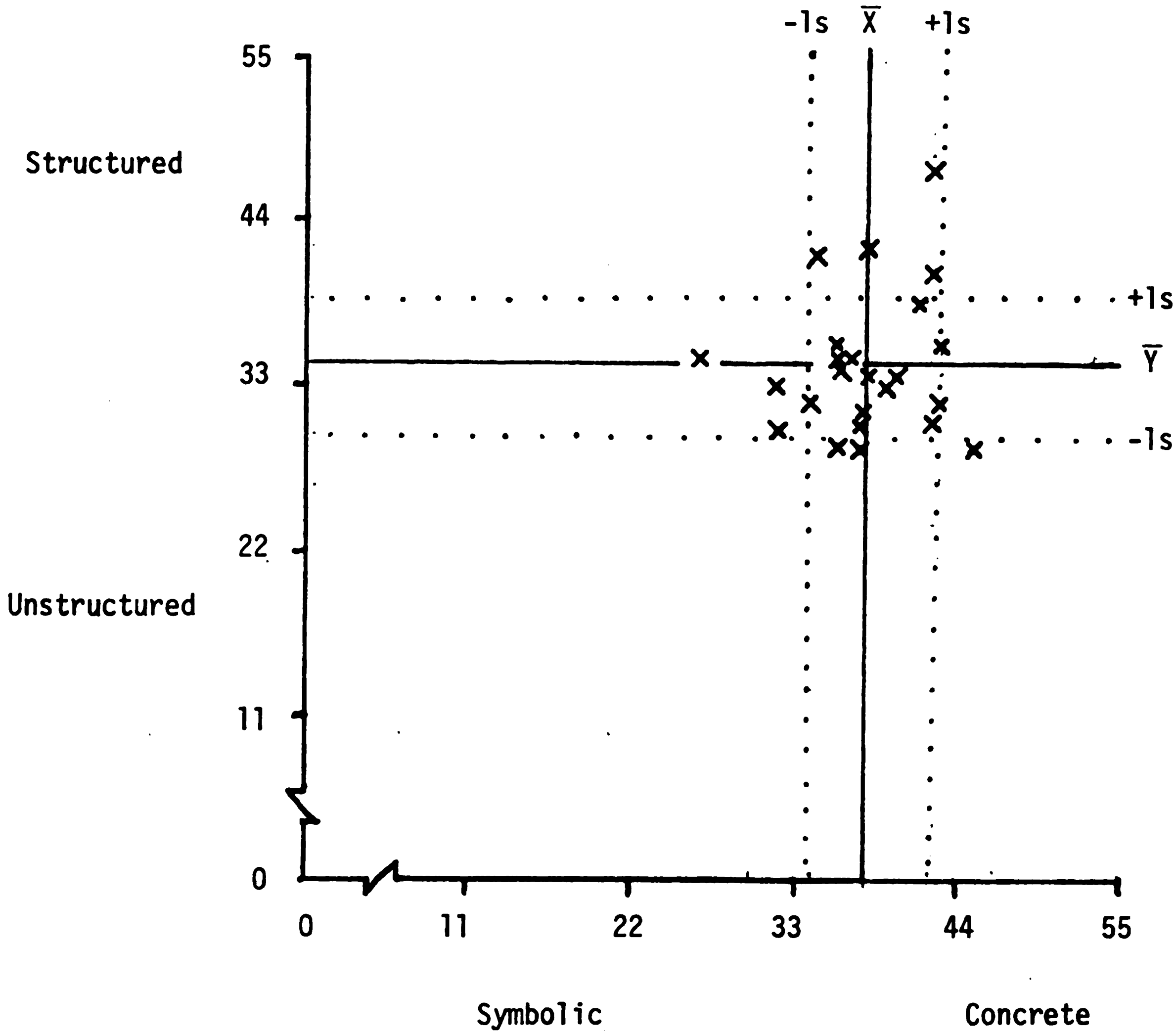
There are considerable numbers of students who attained scores between the two extremes discussed here. These individuals should not be overlooked, but rather be considered as students who would probably achieve best within learning environments which use a mixture of both structured and unstructured learning strategies.

The Learning Activities Survey used in this study yields scores on the concrete/symbolic and the structured/unstructured continua. The two scores that an individual achieves on these may be plotted on a graph, using the two continua as axes. The group means ($\overline{X}$ and $\overline{Y}$) may be shown by lines on the figure, and standard deviation lines (+ and -1s) above and below the mean also. Plotting a group of scores in this manner yields a figure that may be readily interpreted for the learning styles present within the group.

In the figures that follow, the concrete/symbolic continuum lies along the horizontal axis and the structured/unstructured continuum is represented by the vertical axis. The occupational areas of Business, Health, and Trade & Industry are shown respectively as Figures 12, 13, and 14. The scores of the total group are shown in Figure 15.

A brief discussion of Figure 13, that of the Health Occupational Area, will serve to illustrate the concept used in these figures. There are twenty-three students whose scores form various points on the graph. Two of the scores are identical; hence there are only 21 points actually shown on the graph. The exact location for any one individual is determined by the intercept of that student's projected score on the concrete/symbolic continuum (the X-axis) and his projected score on the structured/unstructured continuum (the Y-axis).

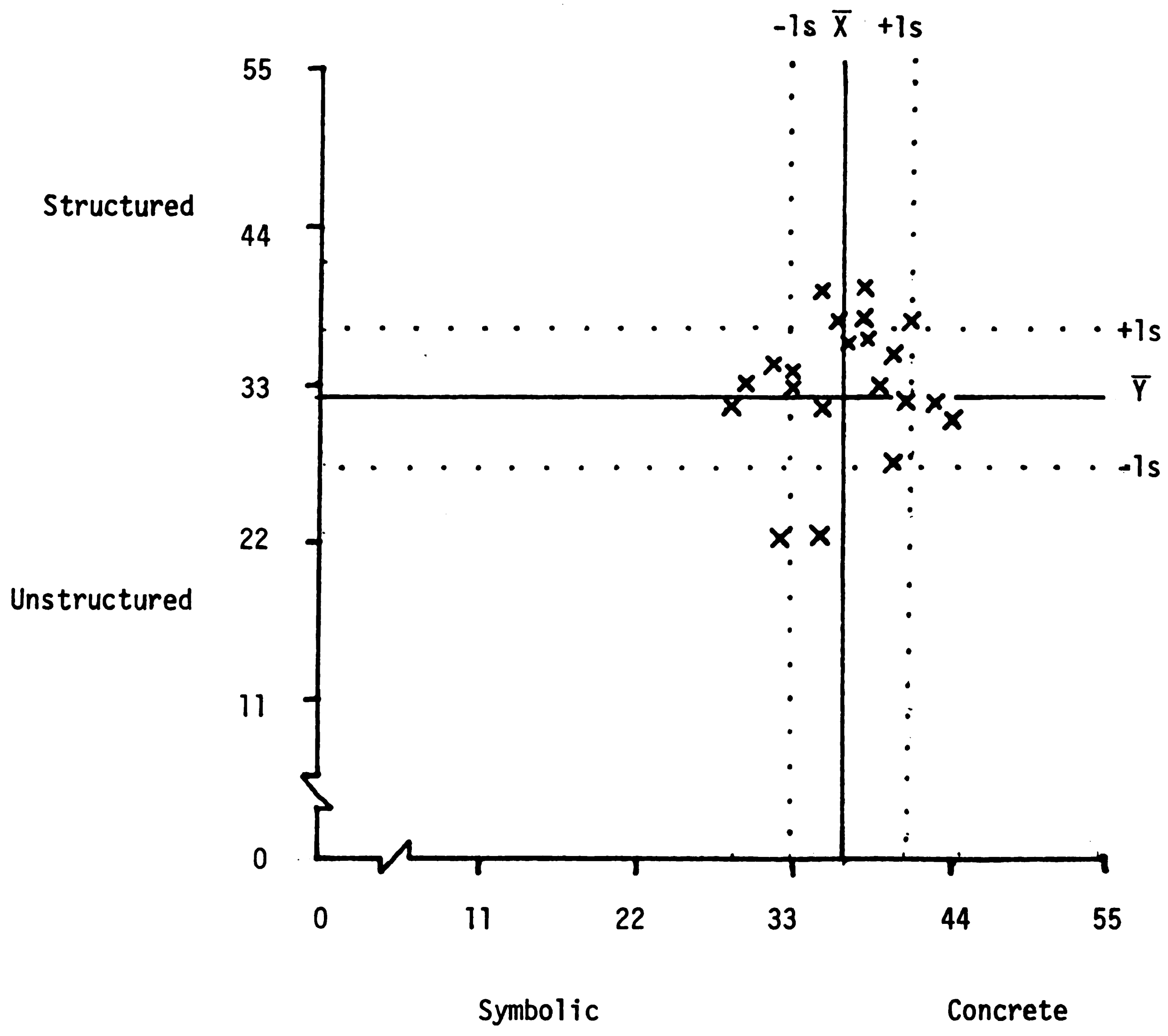
Referring still to Figure 13, it is apparent that fourteen students locate near the midpoint (thirty-three) of the structured/unstructured continuum. The remaining nine individuals locate at points which tend toward one or the other continuum endpoints, and can be seen from the figure to be one standard deviation (1s), or more, above or below the mean. Based on this knowledge, and an understanding of the means and standard deviations, the graph can be visually interpreted, i.e. that some individuals show a desire for either a structured or an unstructured learning strategy. The group



N = 25 $\bar{X}$ = 37.64 St. Dev. = 4.03

$\bar{Y}$ = 34.64 St. Dev. = 4.59

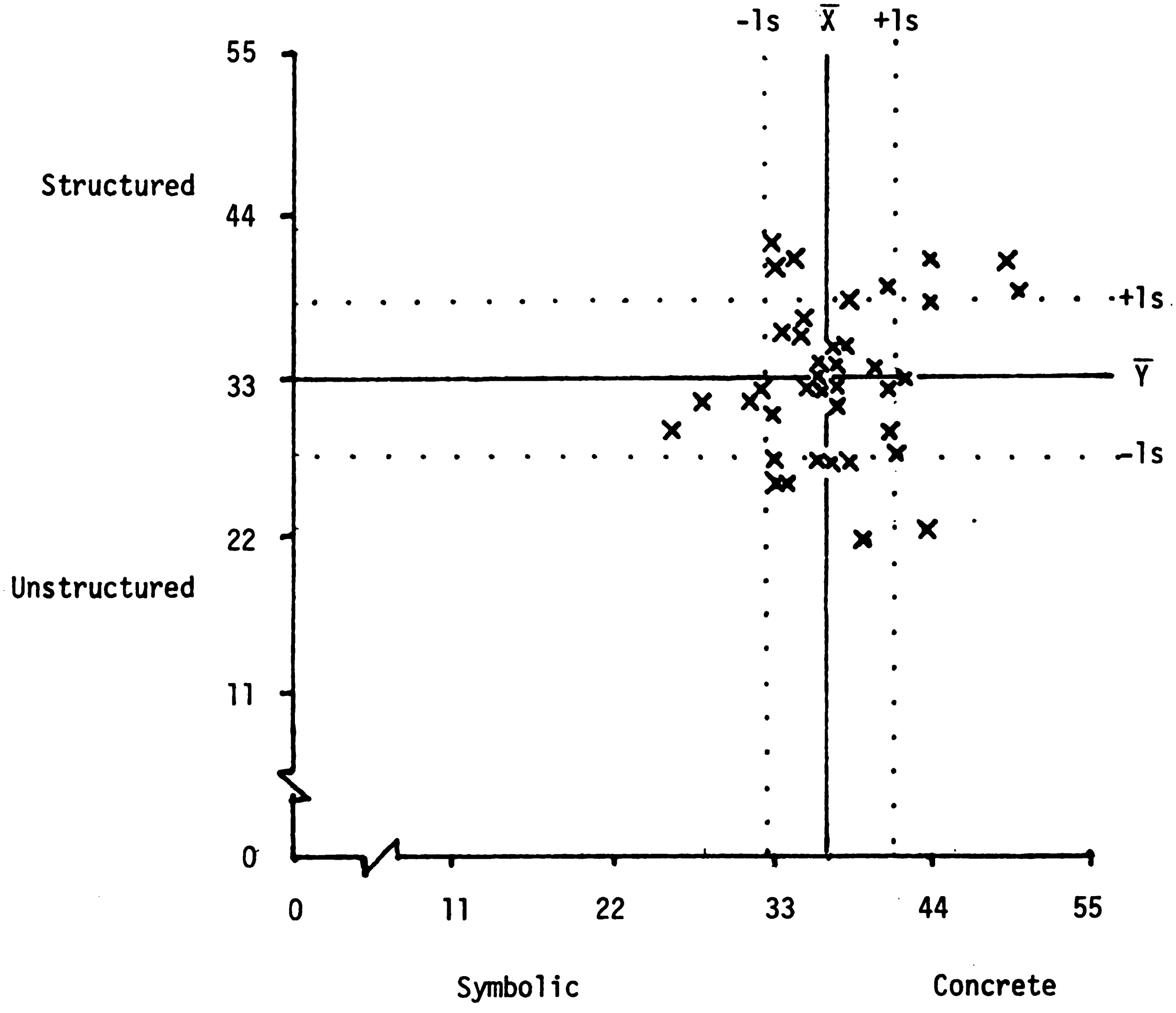
Fig. 12.--Graph showing the scores achieved on the Learning Activities Survey by students from the Business Occupational Area.



N = 23 $\overline{X}$ = 36.57 St. Dev. = 4.02

$\overline{Y}$ = 32.00 St. Dev. = 4.80

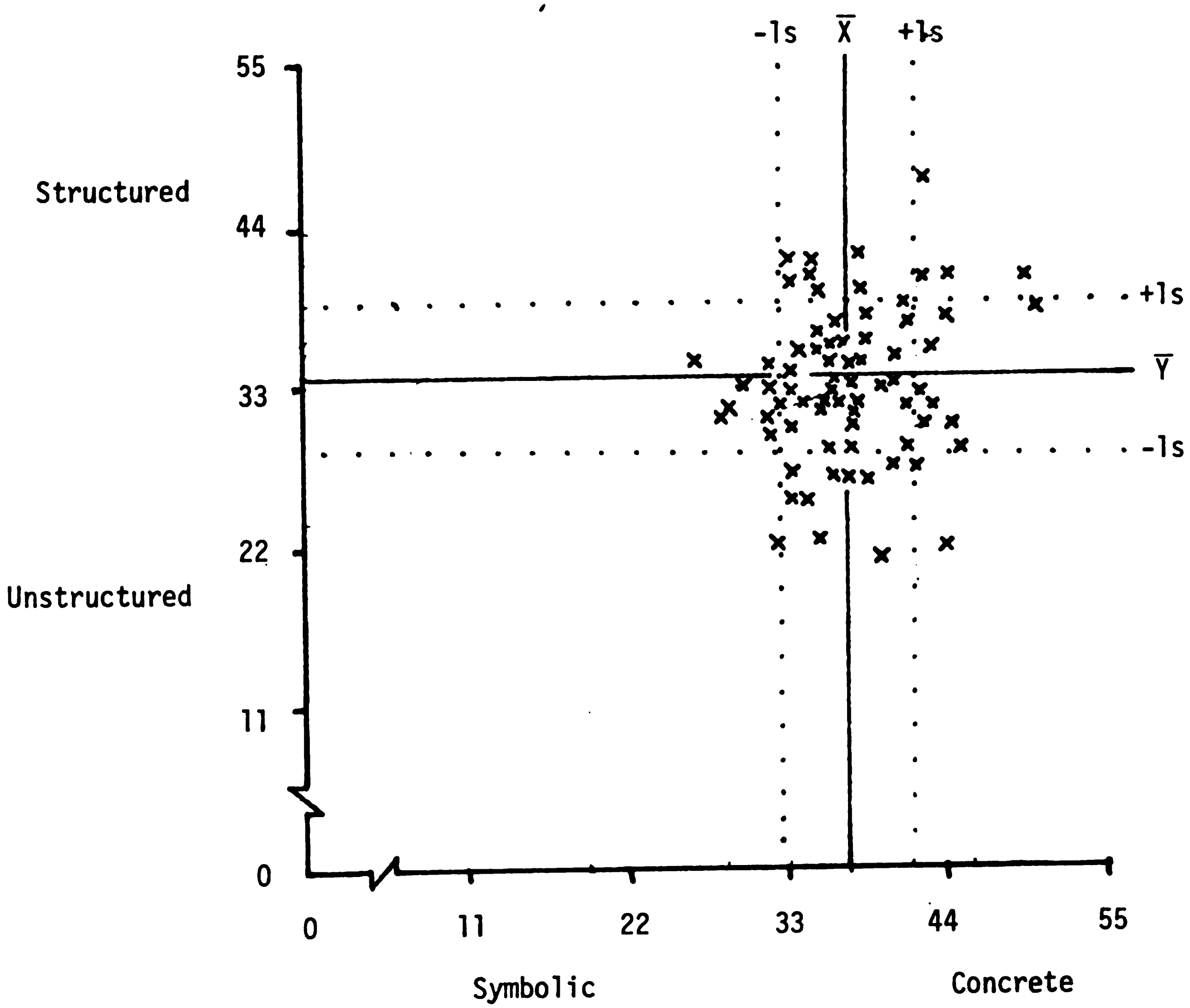
Fig. 13.--Graph showing the scores achieved on the Learning Activities Survey by students from the Health Occupational Area.



N = 44 $\overline{X}$ = 36.89 St. Dev. = 4.36

$\overline{Y}$ = 33.00 St. Dev. = 5.10

Fig. 14.--Graph showing the scores achieved on the Learning Activities Survey by students from the Trade & Industry Occupational Area.



N = 92 $\overline{X}$ = 37.04 St. Dev. = 4.20

$\overline{Y}$ = 33.51 St. Dev. = 4.95

Fig. 15.--Graph showing the scores achieved on the Learning Activities Survey by all students in the sample.

mean of 32.00 indicates that this particular group desires a mixture of learning strategies, since it is relatively close to the midpoint of the continuum. On this basis, it can be argued that alternative modes of instruction should be provided.

Again, looking at the X-axis (concrete/symbolic continuum), fourteen of the twenty-three members of the Health Occupational Area group are located near the point of the group mean (36.57). The remaining individuals are located at points one standard deviation (1s) or more above or below the mean of the group. One individual is located nearly two standard deviations below the group mean, indicating a preference for the symbolic learning style. This individual shows a high mixture of symbolic/structured-unstructured learning styles. Most of the students in the Health Occupational Area show a concrete/structured-unstructured learning style preference.

The other occupational area figures can be inspected and interpreted in a similar manner. Interpretation of these graphs may provide valuable insight into the learning styles of individuals in each group. The dispersion of the points on the graphs is an indication that alternative modes of instruction may need to be provided.

Figure 15 is a composite of the previous three figures. This depicts the variability of the total group on the two continua. The majority of all students participating in the study show a preference for the concrete learning style; more than half of the total group also show a preference for a mixture of structured-unstructured learning styles.

There were ninety-two students whose scores form the various points on the graph of the total group (Fig. 15). Nineteen of the scores were identical; hence, there are only seventy-three points actually shown. Projection lines from both axes are provided for the mean ($\overline{X}$ or $\overline{Y}$) and also one standard deviation above (+1s) and below (-1s) the mean, to aid in the interpretation of the distribution.

The learning style assessment has been discussed in the first section of this chapter. The subjects were randomly selected from the three occupational areas of the Capital Area Career Center. Approximately 10 percent of the students from each occupational area, and consequently from the total enrollment, were used in this experiment. Although seventeen of the twenty-two occupational programs offered at the Center are represented in the sample, not one program had a sufficiently large sample to be considered alone. Consequently, the figures presented allow only for interpretation of the collected learning style data for the Center and the three occupational areas.

The conclusions which were reached are that the students from the Business Occupational Area showed a preference for concrete/structured learning styles, the students from the Health Occupational Area showed a preference for concrete/unstructured learning styles, while the students from the Trade & Industry Occupational Area showed a preference for concrete with a mixture of structured-unstructured learning styles.

Analysis of Learning Data

Another of the objectives of this study was to measure the effectiveness on learning achievement of an experimental matching of learning styles with instructional mode. The assessment of the learning styles of the students in this study was discussed in the previous section of this chapter. This section presents the learning data which were collected as a result of the experimental matching, and a discussion of the results of the learning data analysis.

Learning Scores

The two tables which follow present the means and standard deviations of the learning scores by cell and level of match for the two criteria tests. Table 11 shows the learning scores achieved on the initial learning tests, which were administered immediately after the students had completed the instructional materials. The left column lists the mean scores achieved by the students from all of the occupational areas on the test for conversion within the metric system of measurement. The total group of ninety-two students achieved a mean score of 4.14, with a standard deviation of 2.91. The criterion for a grade of pass on this module (or learning packet) at the Capital Area Career Center was a minimum score of seven correct out of a total of ten questions. Twenty-three (25 percent) of the students achieved this minimum score. The right column lists the mean scores achieved on the test for changing between the metric and customary (English) systems of measurement. The total group (n = 92) achieved a mean score of 1.59 with a standard deviation of 2.12. The criterion for a grade of pass on this module was also a minimum score of seven correct out of a total of ten questions. Only five (5.4 percent) of the ninety-two students comprising the sample population achieved a grade of pass on this module.

Table 11.--Means and standard deviations of learning scores on initial learning tests and number of subjects by cell and level.

Level of Match	Conversion Within Metric System	Change Between the Metric-English Systems
Match (K)[a]	$\overline{X}$ = 4.21 s = 2.89 n = 28	$\overline{X}$ = 1.82 s = 1.79 n = 28
Nonmatch (L)	$\overline{X}$ = 4.41 s = 2.98 n = 27	$\overline{X}$ = 2.04 s = 2.56 n = 27
Mismatch 1 (M)	$\overline{X}$ = 4.05 s = 2.96 n = 20	$\overline{X}$ = 1.65 s = 1.93 n = 20
Mismatch 2 (N)	$\overline{X}$ = 3.71 s = 2.91 n = 17	$\overline{X}$ = 1.00 s = 1.19 n = 17
Total Group	$\overline{X}$ = 4.14 s = 2.91 n = 92	$\overline{X}$ = 1.59 s = 2.12 n = 92

[a]Level of Match code letter refers to letters assigned in the Learning Styles-Treatment matrix (Table 5), p. 71.

Table 12 shows the learning scores on the retention tests which were administered five weeks after the completion of the initial instruction. The instruments used were identical to those used for

the initial learning tests. Due to a number of conflicts which occurred, only fifty-three (57.6 percent) of the ninety-two students in the study were available for retesting (see p. 70). The left column lists the scores which were achieved by the students on the retention test for conversion within the metric system of measurement. The total group of fifty-three students achieved a mean score of 3.17, with a standard deviation of 2.66. Only six (11.3 percent) of fifty-three students

Table 12.--Means and standard deviations of learning scores on retention tests and number of subjects by cell and level.

Level of Match	Conversion Within Metric System	Change Between the Metric-English Systems
Match (K)[a]	$\overline{X}$ = 2.45 s = 2.42 n = 11	$\overline{X}$ = 2.27 s = 2.38 n = 11
Nonmatch (L)	$\overline{X}$ = 3.39 s = 2.19 n = 18	$\overline{X}$ = 1.61 s = 1.53 n = 18
Mismatch 1 (M)	$\overline{X}$ = 3.13 s = 2.45 n = 15	$\overline{X}$ = 1.07 s = 1.48 n = 15
Mismatch 2 (N)	$\overline{X}$ = 3.67 s = 3.43 n = 9	$\overline{X}$ = 0.89 s = 1.29 n = 9
Total Group	$\overline{X}$ = 3.17 s = 2.66 n = 53	$\overline{X}$ = 1.47 s = 1.78 n = 53

[a]Level of Match code leter refers to letters assigned in the Learning Styles-Treatment matrix (Table 5), p. 71.

achieved a grade of pass (minimum score of seven correct) on this retention test. The right column lists the scores achieved on the retention test for changing between the metric and Engligh (customary) systems of measurement. The total group (n = 53) achieved a mean score of 1.47, with a standard deviation of 1.78. None of the fifty-three students achieved a grade of pass on this retention test.

Statistical Analysis

The two learning styles considered along with the two treatments used in this study would have yielded a 2 x 2 x 2 statistical design, that is, a design using concrete/symbolic x structured/unstructured x direct-detailed/directed-discovery. This design would have lent itself well to the analysis of variance and regression analysis as originally considered. Unfortunately, the decision was made that the students would be randomly assigned to one of the two treatment groups without regard for their scores on the Learning Activities Survey. In retrospect, it appears that certain learning styles were poorly represented numerically at the Capital Area Career Center. This led to an imbalance in cell size, which rendered this design unsuitable statistically.

As a result of this imbalance in cell size, the four specific hypotheses (presented on p. 77) could not be tested in the proposed manner. Therefore, it was concluded that the effectiveness on learning achievement of an experimental matching of learning style with instructional mode was inconclusive.

The fifth hypothesis, which considered the student characteristics of sex, age, reading comprehension level, and computational skill in four subcategory hypotheses (see p. 78; a, b, c, and d) was analyzed separately using the stepwise regression technique. The results of this analysis (Table 13) indicated that the student characteristics of sex and reading comprehension level were significant at the 0.05 level. The student characteristics of age and computational skill were found not to be significant. As the student characteristics of sex and reading comprehension level were significant factors, these two characteristics were used as covariates in subsequent analyses of the learning data.

Table 13.--Regression analysis on student characteristics.

Characteristic	F-Value	Degrees of Freedom	Probability
Sex	3.6389	4 and 84	0.0088*
Age	2.0374	4 and 83	0.0967
Reading comprehension level	10.2204	4 and 85	0.0001*
Computational skill			
(a) Whole number	0.9831	4 and 84	0.4214
(b) Decimal number	0.6579	4 and 83	0.6231

*Significant at the 0.05 level.

Two summary tables are presented as a matter of interest. The first, Table 14, shows the means and standard deviations of initial learning scores achieved in this experiment, arranged by sex and instructional mode. It is apparent that, on the average, males did achieve higher mean scores than did females, regardless of the mode of instruction employed.

Table 14.--Summary of initial learning score means by sex.

Instructional Mode	Initial Learning Scores			
	Test 1[a]		Test 2[b]	
	Male	Female	Male	Female
Direct-detailed	$\bar{X}$ = 4.54 s = 3.07 n = 28	$\bar{X}$ = 3.73 s = 0.96 n = 22	$\bar{X}$ = 1.57 s = 2.01 n = 28	$\bar{X}$ = 1.05 s = 2.64 n = 22
Directed-discovery	$\bar{X}$ = 5.77 s = 3.04 n = 22	$\bar{X}$ = 2.75 s = 1.79 n = 20	$\bar{X}$ = 2.45 s = 2.53 n = 22	$\bar{X}$ = 1.25 s = 1.86 n = 20

[a]Test on change within the metric system.

[b]Test on conversion between the metric-English systems.

The second, Table 15, shows the mean scores of students on the initial learning test arranged by reading comprehension level and instructional mode. The reading comprehension level grades were separated into three arbitrary groups (high, mid, and low level readers). The high level was set at the eleventh grade or higher, the mid level between ninth and eleventh, and the low level consisted of those reading below the ninth grade level. As even a cursory inspection of Table 15 will show, there was a definite, positive correlation between the reading level of the students and the mean scores achieved, regardless of the treatment.

Table 15.--Summary of mean scores by reading level and instructional mode.

Instructional Mode and Test	Reading Comprehension Level		
	High > 11.0	Mid 9-10.9	Low < 8.9
Direct-detailed Test 1[a]	$\bar{X}$ = 7.14 n = 7	$\bar{X}$ = 3.89 n = 29	$\bar{X}$ = 2.62 n = 13
Directed-discovery Test 1[a]	$\bar{X}$ = 6.06 n = 17	$\bar{X}$ = 5.00 n = 16	$\bar{X}$ = 1.40 n = 10
Direct-detailed Test 2[b]	$\bar{X}$ = 3.14 n = 7	$\bar{X}$ = 1.34 n = 29	$\bar{X}$ = 0.13 n = 13
Directed-discovery Test 2[b]	$\bar{X}$ = 3.47 n = 17	$\bar{X}$ = 1.46 n = 16	$\bar{X}$ = 0.10 n = 10

[a]Test on change within the metric system.

[b]Test on conversion between the metric-English systems.

Before further analysis is considered, it is useful to summarize the results obtained thus far. With regard to the four specific hypotheses considered, relative to the effectiveness on learning achievement of an experimental matching, the results were inconclusive. The fifth hypothesis was tested using the stepwise regression technique. With regard to the student characteristics of age, sex, reading comprehension level, and computational skill, only sex and reading comprehension level were found to be significant factors.

Hypotheses on matching.--After studying the learning assessment data, and the collected learning data on the use of the instructional materials in this experimental study, the conclusion was reached that several questions could be asked. These questions address themselves to the original hypotheses presented in Chapter III. The questions, which relate to the results of the experiment, are:

1. Do the students who prefer the concrete learning style differ in overall achievement from those who prefer the symbolic learning style?
2. Do the students who prefer the structured learning style differ in overall achievement from those who prefer the unstructured learning style?
3. Is the effect on the overall achievement of the direct-detailed instructional mode different from the effect of the directed-discovery instructional mode?
4. Does the matched group (K) as a whole tend to differ in overall achievement from the nonmatched group (L) as a whole?
5. Does the mismatched 1 group (M) as a whole tend to differ in overall achievement from the mismatched 2 group (N) as a whole?

In order to consider these five questions, the collected data needed to be rearranged into eight cells, as shown in Table 16. The eight cells, or types of interest, are derived from the two learning style continua as measured on the Learning Activities Survey, and the two instructional modes, or treatments, used in this experiment. The resultant number of students in each cell is shown in the frequency column.

Table 16.--Cell identification and frequencies.

Cell	Learning Style x Instructional Mode	Frequency
1	Concrete/Structured x Direct-Detailed	25
2	Concrete/Structured x Directed-Discovery	22
3	Concrete/Unstructured x Direct-Detailed	16
4	Concrete/Unstructured x Directed-Discovery	14
5	Symbolic/Structured x Direct-Detailed	3
6	Symbolic/Structured x Directed-Discovery	4
7	Symbolic/Unstructured x Direct-Detailed	5
8	Symbolic/Unstructured x Directed-Discovery	3
	Total	92

In order to analyze these rearranged data, the technique of one-way multivariate analysis of covariance with planned comparisons was performed. It had previously been determined, by a stepwise regression technique, that the student characteristics of sex and reading comprehension level do influence the students' overall achievement on this experiment (see Table 13), and to verify that sex and reading comprehension level could still be used as the covariates, a second regression analysis was performed on the rearranged data. Using 2 and 82 degrees of freedom, and the 0.05 level of significance, the two covariates were found to be of significance in every test. Table 17 summarizes this analysis.

Table 17.--Statistics for regression analysis with two covariates.

Variable	F	P<	% of Variance of Test Accounted for
Initial learning--within metrics test	17.0966	0.0001	29.43%
Initial learning--between metric-English test	13.2526	0.0001	24.43
Retention--within metrics test	5.1124	0.0081	11.09
Retention--between metric-English test	4.7681	0.0110	10.42

The five questions presented previously were developed into five secondary hypotheses. These secondary hypotheses were tested using the one-way multivariate analysis of covariance with planned comparisons. Following the statement of each secondary hypothesis is a discussion of the statistical analysis as it pertains to that particular hypothesis.

> Secondary Hypothesis 1: There is no difference in overall achievement between students who indicate a preference for the concrete learning style and students who indicate a preference for the symbolic learning style.

The multivariate test of equality of mean vectors indicated an F-ratio of 1.2938, using 4 and 79 degrees of freedom. The probability of this large a value occurring due to chance alone is less than 0.2797. Using the 0.05 level of significance, the conclusion was reached that this hypothesis cannot be rejected.

Secondary Hypothesis 2: There is no difference in overall achievement between students who indicate a preference for the structured learning style and students who indicate a preference for the unstructured learning style.

The multivariate test of equality of mean vectors indicated an F-ratio of 0.6310, using 4 and 79 degrees of freedom. The probability of this large a value occurring due to chance alone is less than 0.6419. Using the 0.05 level of significance, it was concluded that this hypothesis cannot be rejected.

Secondary Hypothesis 3: There is no difference between the effect of the direct-detailed instructional mode and the effect of the directed-discovery instructional mode on the overall achievement of the students.

The multivariate test of equality of mean vectors indicates an F-ratio of 1.0197, using 4 and 79 degrees of freedom. The probability of this large a value occurring due to chance alone is less than 0.4024. Using the 0.05 level of significance, it was concluded that this hypothesis cannot be rejected.

Secondary Hypothesis 4: There is no difference between the matched groups as a whole and the nonmatched groups as a whole on overall achievement.

The multivariate test of equality of mean vectors indicated an F-ratio of 0.3515, using 4 and 79 degrees of freedom. The probability of this large a value occurring due to chance alone is less than 0.8423. Using the 0.05 level of significance, the conclusion was reached that this hypothesis cannot be rejected.

Secondary Hypothesis 5: There is no difference between the mismatched 1 groups as a whole and the mismatched 2 groups as a whole on overall achievement.

The multivariate test of equality of mean vectors indicated an F-ratio of 0.9350, using 4 and 79 degrees of freedom. The probability of this large a value occurring due to chance alone is 0.4482. Using the 0.05 level of significance, it was therefore concluded that this hypothesis also cannot be rejected.

Discussion

The original intent of this study was to test for the efficacy on overall achievement of an experimental matching between learning style and instructional mode. However, the proposed statistical analysis was not carried out due to the inadequacy of the learning data which were obtained. An error was made in randomly assigning subjects to treatments before the analysis of the data collected from the administration of the Learning Activities Survey was completed. The possibility that there would be a great disparity in numbers of students preferring the various learning styles had not been foreseen.

This error, of randomly assigning subjects to treatments before the analysis of the data collected from the administration of the Learning Activities Survey was completed, was identified as one of the confounding variables in this experimental study. It was concluded that in order to avoid this error in subsequent studies of this nature, the Learning Activities Survey should be administered first and the learning assessment data analyzed for the number of students per cell of the level of learning style. From these students, equal numbers should be randomly chosen to fit the learning styles-treatments matrix of Table 5 (see p. 71). These subjects then should be used for the subsequent part of the experiment involving the use of the learning materials under the two instructional modes.

Since this error was made, the resultant imbalance of frequencies in the various cells would have yielded meaningless results from the proposed level-by-treatment analysis.

A second problem that occurred in this study was that a small percentage of the students who participated in the learning exercise actually achieved criterion level (pass = a minimum grade of seven) on the initial learning tests. Thus, a large number of students (who had not learned the material originally) could not be expected to achieve criterion level on the retention test, as was indeed the case. These numbers, shown in Table 18, illustrate that there were too few individuals in any one cell to yield meaningful results from statistical analysis.

Table 18.--Number of students who achieved criterion-level on initial learning and retention tests by level of match.

Level of Match	Initial Learning		Retention	
	Metric System	Metric-English Systems	Metric System	Metric-English Systems
Match (K)[a]	7	1	1	0
Nonmatch (L)	7	3	2	0
Mismatch 1 (M)	6	1	2	0
Mismatch 2 (N)	3	0	1	0
Total	23	5	6	0

[a]Level of Match code letter refers to letters assigned in the Learning Styles-Treatment matrix (Table 5), p. 71.

This small percentage of students who achieved criterion level on the initial learning test was identified as the second confounding variable. Had a meaningful balance in cell size been achieved, using the random assignment to treatments as carried out in this experiment, the collected data would still have been difficult to analyze for meaningful results.

The several factors which may have contributed to the large number of students who failed to achieve the criterion level on the initial learning and retention tests were identified as: (a) the enforced nonrepetition of the learning materials once the tests had been attempted, (b) the absence of interaction between the student and the instructor during the initial learning session, (c) the newness of the instructional materials to the students. It was reasoned that, to a lesser extent, the factors of (a) the overall time limitation, (b) the presentation of the learning materials to the students in a reading format only, (c) the lack of interest for the content of the instructional materials by the students, and (d) the possible complexity of the learning materials may all have contributed to the result of more students not achieving criterion level. What had appeared to the experimenter as a fairly simple task may have been perceived by the students as being quite complex and different from their normal routine at the Center.

The student characteristics of sex and reading comprehension level were found to be significant factors in the interaction between student characteristics and instructional mode (see Tables 13 and 17). The five secondary hypotheses were tested using the one-way multivariate analysis of covariance with planned comparisons. Using the 0.05 level of significance, it was found that none of these five secondary hypotheses could be rejected. This reiterates the conclusion that the effectiveness on overall achievement of the experimental matching of learning style with instructional mode was inconclusive.

Summary

This chapter contains the presentation and discussion of the major findings of the study. The first three objectives of the study were discussed, while the fourth objective will be considered in the next chapter. The chapter was divided into two major sections, the first relating to the learning style assessment and the second dealing with the analysis of the learning data.

The assessment of the learning styles of the students at the Capital Area Career Center was discussed in the first section of this chapter. With the learning styles identified and the distribution of the learning style scores presented, it was concluded that the first objective of this study had been fulfilled. Graphs were included which show the distribution of the scores by occupational area and for the group as a whole. These figures may be readily interpreted for the learning styles within the occupational areas or of the group.

A brief summary of the findings shows that the students from the Business Occupational Area preferred the concrete/structured styles, while the students from the Health Occupational Area favored the concrete/unstructured styles. The students from the Trade & Industry Occupational Area, and the group as a whole, showed a preference for the concrete with a mixture of structured/unstructured styles.

The second section of the chapter contains the presentation and discussion of the learning data analysis. It was concluded that the second objective of this study was not fully met. The results of the measurement of the effectiveness on achievement of an experimental matching of learning style with instructional mode were inconclusive. Two confounding variables hindered the testing of the hypotheses relating to the experimental matching. These variables were identified as (a) the disparity in the distribution of numbers of students who preferred the various learning styles, and (b) the small percentage of students who achieved the criterion level on the initial learning and retention tests.

Several questions were then presented which addressed themselves to the second objective of the study. The collected learning data were rearranged in order to test the five secondary hypotheses with regard to these questions. None of the hypotheses was rejected, using the 0.05 level of significance. This reinforced the conclusion that the experimental matching which was attempted in this study yielded inconclusive results.

The second section of the chapter contains the discussion of the third objective of this study. The technique of regression analysis was used to determine the existence of interactions between student characteristics (age, sex, reading comprehension level, and computational skill) and overall achievement. It was found that the characteristics of sex and reading comprehension level did contribute to overall achievement. No interactions were found for the other two student characteristics--age and computational skill. It was concluded that the third objective of this study had been met.

The next chapter contains the discussion of the fourth objective of the study--the recommendations to the Center. The chapter also contains the summary, conclusions, and suggestions for further research.

CHAPTER V

SUMMARY AND SYNTHESIS

Summary

This experimental study is reported in five chapters. Chapter I contains the statement of the problem and its significance. In the statement of the problem, the four objectives of this study were identified. They are:

1. to identify the learning styles of the students in the various occupational areas at the Capital Area Career Center in Mason, Michigan;
2. to measure the effectiveness on achievement of an experimental matching of learning style with instructional mode;
3. to measure the extent to which the student characteristics of sex, age, reading comprehension level, and computational skills relate to achievement; and
4. to identify and recommend directions for ongoing and future curriculum development in the light of the measured learning styles of the students.

Chapter II contains the review of related research. The topics reviewed were: (1) individual differences, (2) modes of instruction, and (3) learning styles.

The format of the experiment is described in Chapter III. The rationale for the use of the learning materials is presented. These

learning materials relate to the use of the metric system and conversions between the metric and customary systems. Students at the Capital Area Career Center served as subjects for the study.

The Learning Activities Survey, used to identify the preferred learning style of the student, is also described. The chapter concludes with a description of the statistical treatment and a presentation of the specific hypotheses which were considered.

Chapter IV contains the results of the experiment. The chapter is divided into two major sections: (1) assessment of learning styles and (2) analysis of the learning data. The results of the assessment of the learning styles of the students at the Capital Area Career Center are presented and discussed. The distribution of scores in each of the three occupational areas is displayed graphically.

The results of the experimental matching of student learning style and instructional mode were inconclusive. Two confounding variables were identified, and therefore the first two hypotheses could not be tested as originally planned. However, in regard to the third hypothesis, interactions were found to exist between the student characteristics of sex and reading comprehension level and the two instructional modes used. No interactions were found on the student characteristics of age or computational skills.

Five secondary hypotheses were then posed. These relate to the overall results of the experiment. Using the collected learning data in a rearranged format, along with another statistical technique, these secondary hypotheses were not rejected.

Chapter V is divided into the following five sections: (1) Summary, (2) Conclusions, (3) Limitations, (4) Recommendations, and (5) Suggestions for Further Research. The summary has been presented and the next section will deal with the conclusions which were reached as a result of this study. The section on limitations relates to those limitations that are a direct result of having undertaken this study, and are presented in addition to those previously listed in Chapter I. The recommendations which are made relate specifically to the Capital Area Career Center in regard to their ongoing and future curriculum revisions. This section discusses the fourth objective of the study. The final section, Suggestions for Further Research, lists a number of suggestions of possible directions for future research with regard to the experimental matching which was considered in this study.

Conclusions

On the basis of the results obtained under the conditions of this study, several conclusions seem warranted. These conclusions follow, grouped in order of their relation to each of the four objectives of this study.

Objective 1: To identify the learning styles of the students in the various occupational areas at the Capital Area Career Center in Mason, Michigan.

Learning style assessment of the students at the Capital Area Career Center yielded valuable information and insight. The instrument which was used, the Learning Activities Survey, measured learning style on two continua, concrete/symbolic and structured/unstructured.

The following conclusions were reached as a result of the assessment:

1. It is possible to provide a visual display of the distribution of the learning styles (see Figures 12, 13, 14, and 15, pp. 104-107). These figures may be readily interpreted to provide insight into the learning styles preferred by students in each occupational area and in the Center as a whole.

2. The population of the Center is composed of students who prefer a number of different learning styles. The Learning Activities Survey did measure a preference for each of the four possible learning style combinations among the students at the Center. There were individual learners who indicated a preference for concrete/unstructured, concrete/structured, symbolic/unstructured, and symbolic/structured.

3. The students at the Center show a preference (in general) for the concrete learning style, indicating that they prefer "hands-on" activities as a means of learning.

4. The students at the Center show a preference (in general) for a mixture of the structured/unstructured learning styles, indicating that they prefer a mixture of highly organized activities with self-organized and self-paced activities.

5. With regard to each of the three occupational areas at the Center, the following conclusions can be made:

a. Students of the Business Occupational Area showed a preference for the concrete/structured styles. This indicates that (in general) the students in this area prefer "hands-on" activities that are highly organized.

b. Students from the Health Occupational Area showed a preference for the concrete/unstructured styles. This indicates that these students (in general) prefer "hands-on" activities that are self-organized and self-paced.

c. Students from the Trade & Industry Occupational Area showed a preference for the concrete with a mixture of the structured/unstructured styles. This indicates that these students (in general) prefer "hands-on" activities that are a mixture of highly organized and self-organized and self-paced activities.

Objective 2: To measure the effectiveness on achievement of an experimental matching of learning style with instructional mode.

Part of the intent of this study was to attempt an experimental matching of learning style and instructional mode. On the basis of the results obtained, it was concluded that the effectiveness of the experimental matching was inconclusive.

Two confounding variables were identified which impeded the proposed analysis of the learning data. Random assignment of subjects to the treatments was concluded prior to the analysis of the learning style assessment data; also there was a high frequency of scores below the criterion level on both the initial learning and retention tests.

It was concluded that the error of random assignment to treatments before the analysis of the learning style assessment yielded an unbalanced learning style matrix for the sample used. A better technique would have been to administer the Learning Activities Survey to a larger sample, analyze these data for the distribution of student preferences for each cell of the learning style matrix, and then draw an equalized random sample from each cell for participation in the subsequent part of the experiment.

Several factors which may have contributed to the large numbers of students who failed to reach the criterion level on the initial learning and retention tests were identified. Some of these were imposed as controls in the experiment, while others relate to the content of the learning materials and the motivation of the students. It was concluded that what appeared to be a relatively simple task may have been perceived by the students as being quite complex and different from their normal routine at the Center.

The inconclusive nature of the initial analysis of the learning data directed the researcher to try to meet the second objective via a different route. Several questions were formulated to address the original hypothesis. These questions were restated as five secondary hypotheses.

None of the secondary hypotheses was rejected. The conclusion reached was that there was no difference in the overall achievement of the students in this study regardless of the students' preferred learning style, the instructional modes employed, or the experimental matching or nonmatching achieved.

<u>Objective 3</u>: To measure the extent to which the student characteristics of sex, age, reading comprehension level, and computational skills relate to achievement.

Other researchers have identified several student characteristics that were considered as possible indicators of overall student achievement. The four student characteristics that were used in this study are age, sex, reading comprehension level, and computational skill.

On the basis of the results obtained in this study, it was concluded that the instructional modes employed were more effective with one of the sexes, and that there was a positive correlation between the reading comprehension level of the student and his/her overall achievement. No interactions were found to exist on the student characteristics of age and computational skill.

Objective 4: To identify and recommend directions for ongoing and future curriculum development in the light of the measured learning styles of the students.

The presence of differing learning styles among the students attending the Center was demonstrated. However, the inconclusive nature of the experimental matching makes the results of this study less useful for formulating and recommending directions for curriculum development than might have been expected.

It was concluded that the staff of the Center may find that the individual student's identified learning style is a useful indicator in the diagnosis of the student's learning difficulties at the Center. The recommendations for the Center in regard to this objective are discussed fully in a subsequent section of this chapter.

Limitations

Before discussing the recommendations of this study, consideration should be given to the several limitations of the study. These limitations are presented in addition to those which were previously discussed in the first chapter of the study.

1. The subjects used in this study were randomly selected by the General Learnings Coordinator from the total number of students attending the Capital Area Career Center. The subjects were grouped by occupational area rather than by occupational program, due to the small numbers representing each program. It is therefore not possible to draw any inferences about the individual occupational programs. Since the mixture of occupational programs in each occupational area may differ from one area skill center to another, generalization is only possible concerning the occupational areas at the Capital Area Career Center and the Capital Area Career Center itself.

2. In the second chapter of this study, it was indicated that other learning styles exist, as well as other learner variables. No attempt is made to imply that the variables which were used in this study are the only significant ones. When dealing with individuals and their learning characteristics, many variables are involved, and among these variables is learning style.

3. Only two instructional modes were selected, one of which closely parallels the one in use at the Capital Area Career Center. The related research indicated the existence of other instructional modes. The instructional materials were presented to the student in a reading format, which is the format in use at the Center. No attempt is made to imply that these modes are the only significant ones; they were imposed merely for control purposes.

4. During the period of instruction, discussion and/or questions were not allowed. Only one period, of approximately 2-1/4 hours, was provided for the completion of the two mods. Although a student could repeat an instructional packet as often as desired before attempting the test for that mod, no repetition of the learning materials was permitted after completion of the test. These were necessary constraints, imposed for control purposes, but are factors which differentiate the learning process of this experiment from that of the typical Center experience.

5. Another possible limitation of this study may be the instructional materials (or mods) which were written and used in this study only. Although the author had had prior experience in writing curricular materials for use at the Center, the instructional materials used in this study had not been tested with students at the Center prior to this study. It is possible, therefore, that these learning materials failed to some extent to serve the intended purpose.

Recommendations

The results of this study have a direct impact on the fourth objective. The first three objectives were discussed in Chapter IV, while the fourth, because of its nature, properly belongs here in Chapter V. The fourth objective, as presented in Chapter I, is

> to identify and recommend directions for ongoing and future curriculum development, in light of the measured learning styles of the students.

It had been anticipated that the result of meeting the first three objectives would allow for the identification and subsequent recommendations for curriculum development at the Center. However, since only the first and third objectives were met fully, while the second objective yielded inconclusive results, the recommendations that can be made to the Center are more limited. The subsequent discussion and recommendations are made in light of the results which were obtained.

A variety of learning style combinations exists among the students at the Center, as is evident from an inspection of Figure 15 (p. 107). This figure shows the distribution of scores on the Learning Activities Survey for the total group. Points, representing individual group members, occur in each of the four quadrants formed by the projections of the midpoints of the two continua. Figures 12, 13, and 14 display similar data for each of the occupational areas.

It is evident from these figures that, at the Center, and in each occupational area, there were students who displayed a preference for each of the four learning styles: (1) concrete/structured, (2) concrete/unstructured, (3) symbolic/unstructured, and (4) symbolic/structured. Some individuals, at or near the midpoint of the continuum, showed a preference for a combination of several learning styles.

The experimental matching performed in this study neither proved nor disproved the premise that matching between learning style and instructional mode would be of benefit to the student in terms of his/her overall learning achievement. The works of Tallmadge and Shearer, Hill and Nunney, Oen, and others appear to indicate that a match is of benefit.

Considering the student characteristics of sex, age, reading comprehension level, and computational skill, significant interactions were found to exist between sex and reading comprehension level and the instructional modes employed in this study.

It is evident from a perusal of Table 13 (p. 114) that males did better than females when the content of the learning materials relates to mathematics. It also appears (see Table 14, p. 115) that the higher the reading comprehension level of a student, the more likely that he/she will succeed with learning materials that are in a reading format.

The recommendations that are made, then, to the Capital Area Career Center are:

1. The identification of the preferred learning styles, as measured in this study, is an indication of the range of interests among the students. The staff at the Center may wish to consider these differing learning styles when developing mods, or even in their routine classroom operations.

2. That there be further exploration into the use of learning style preference questionnaires in order to provide more insight into learning difficulties of individual students.

3. Research has indicated a need for concern about learning style in the development of curricula. This study measured learning style on two continua, but the experimental matching performed on these using the two selected instructional modes proved inconclusive. It is recommended that the Center consider a longer-term study, controlling for the two confounding variables which have been identified.

4. Learning styles and instructional modes, other than those used for this experiment. The Center may wish to explore these, as

one or more may prove more pertinent to the success of the educational process.

5. The significant interaction exhibited between the student characteristics of reading comprehension level and instructional mode yields the recommendation that every student should be helped to improve his/her reading comprehension level. A corollary to this would be to develop mods which are less dependent upon the student's reading comprehension.

6. The significant interaction exhibited between the student characteristic of sex and instructional modes yields a recommendation that is somewhat cautious because of the nature and content of the instructional materials used. It is recommended that the Center explore the relation between this characteristic and overall achievement.

Suggestions for Further Research

With all the collected data analyzed, and the results tabulated, a number of questions remain unanswered. Other, new questions have occurred as a result of the study itself. These questions may well form the basis of worthwhile future research. Some avenues of research that should be more fully explored are:

1. The replication of the concept of this study with the additional requirement of criterion level achievement on initial learning tests.
2. The replication of the concept of this study, using students from an area which could continue the experiment over a much longer period of time.

3. The application of the concept of this study to an experiment using a nonindividualized instructional setting, such as the traditional classroom.
4. The application of the concept of this study to an experiment using a setting where multi-sensory instructional modes are used.
5. The replication of the concept of this study with assessment of learning style being done <u>prior</u> to the assignment to treatment groups, thus ensuring equal cell sizes.
6. The replication of the concept of this study using students from a specific occupational program rather than using all students through a generalized learnings area.
7. The application of the concept of this study to an experiment using different learning style measurements and, possibly, other instructional modes.

APPENDICES

APPENDIX A

LEARNING MATERIALS AND TESTS

REA 446113 INTERCHANGE UNITS WITHIN THE METRIC SYSTEM

INSTRUCTIONAL MATERIALS (FORM A)

You can be one of the first ready to use the Metric System. It is easy, once you learn the new names. Don't let anyone scare you away from it, just dig in and be "one of the first".

The Metric System is really much easier to use than the English System. There are just three new names to learn: the METER, which is used for length or distance measurements; the GRAM, which is used for mass or weight measurements; and the LITER, which is used for liquid volume measurements. There are other names also, but for now, you will study only these three. To these names of measurement, are added prefixes, of which the three most commonly used are kilo-, centi-, and milli.

For example, in measuring length, you can have a millimeter, a centimeter, a meter, or a kilometer.

It is these prefixes that make the Metric System so very easy to use. The prefixes are all related to each other by multiples of ten (10). You are already familiar with multiples of ten from our everyday counting system. Our counting or number system is a decimal system. Look at the way we add the following group of numbers -

	hundreds	tens	units
		1	2
		2	7
			3
		8	2
Answer	1	2	4

Adding the units column first, we get 14; you write down a 4 (in the answer row) and carry the 10 (from 14 = 10 + 4) into the tens column as a 1.

Adding the tens column, we get 12; you write down a 2 (in the answer row) and carry the 10 (from 12 = 10 + 2) into the hundreds column as a 1.

Since there are no other numbers in the hundreds column, you have nothing to add to the 1 carried over, and so you simply write the 1 in the answer in the hundreds column.

We therefore say that our number system is a decimal system because it centers around the base 10, and the prefix deci- means 10. It takes 10-units to make 1-tens, and it takes 10-tens to make 1-hundreds.

Now, let's try and learn what the prefix names mean. First, look at the following

Kilo- = 1000
centi- = 1/100 = .01
milli- = 1/1000 = .001

The prefix Kilo- means 1000 times whatever word it is attached to. You may be familiar with it from an electric bill, where the power used is measured in Kilowatts. In the Metric System, we can have a length of 1 Kilometer or 1000 meters. Likewise, we can weigh 1 Kilogram of meat or 1000 grams, and we might buy 1 Kiloliter or 1000 liters of fuel-oil. The capital letter K is used for Kilo- (Km., Kg., and Kl.).

The prefix centi- means 1/100 of, or .01 times whatever word it is attached to. Centi- is just like the word for penny in our money system. One cent is 1/100 of a dollar, or $ .01. Since you already know that it takes 100 cents to make a dollar, it should be simple to learn that 100 centimeters make a meter. Or, you could say that 1 centimeter is 1/100 of a meter. Likewise, 1 centigram is 1/100 of a gram, and 1 centiliter is 1/100 of a liter. The small letter c is used for centi- (cm., cg., and cl.).

Finally, the prefix milli- means 1/1000 of, or .001 times the word that it is attached to. Remember that some of our cigarettes are advertised as being 100 mm., or 100 millimeters long. One is even advertised as being 'a silly millimeter longer'. Actually, milli- is a very small part, and one millimeter is about the width of a pencil line. You will also find some of the harmful ingredients of cigarettes listed as so many milligrams of tar, nicotene, etc. This is a very small quantity by weight. Volume measurements are made in milliliters, which are sometimes also called cubic centimeters. For example, the displacement of many motorcycle engines is measured in cubic centimeters (cc.), like a 350 cc. Honda. A can of floor wax may contain 800 ml. or 800 milliliters of liquid wax. The small letter m is used for milli- (mm., mg., and ml.).

To summarize then, look at the following chart

NAME	USED FOR	LETTER
Meter	length or distance	m.
Gram	mass or weight	g.
Liter	liquid volume	l.

PREFIX AND NAME	LETTERS	MEANING	
Kilometer	Km.	1000 meters	
centimeter	cm.	.01 meter	length
millimeter	mm.	.001 meter	
Kilogram	Kg.	1000 grams	
centigram	cg.	.01 gram	mass
milligram	mg.	.001 gram	
Kiloliter	Kl.	1000 liters	
centiliter	cl.	.01 liter	volume
milliliter	ml.	.001 liter	

Here are some problems of conversions within the Metric System for you to read and try. Conversions mean changes. For example, if the distance from your school to the Career Center is 5.4 Km., then the distance in meters is 5400, or 5.4 x 1000 = 5400 meters.

If you live 16.5 Km. (16.5 Kilometers) from the Career Center [about 10 miles] then the distance in meters can be found by multiplying the 16.5 by 1000 (for Kilo-) and the distance would be 16,500 meters.

Suppose you are 1.6 m. (1.6 meters) tall, how many centimeters would that be? 1.6 m. x 100 = 160 cm. Remember, 1 centimeter is .01 meter and it takes 100 cm. to make 1 meter.

Thinking of the 100 mm. cigarette, how long would it be in cm. and m.? Let's see, 1 mm. = .001 m., then that should mean that if you multiplied the 100 mm. by .001, you would have the answer in meters, or

$$\begin{array}{r} 100 \text{ mm.} \\ \times\ .001 \\ \hline 100 \\ 000 \\ 000 \\ \hline 00.100 \text{ meters} \end{array}$$

And since 1 cm. = .01 m. while 1 mm. = .001 m.

that must mean that 1 cm. = 10 mm.

Then 100 mm. cigarette ÷ 10 mm. per 1 cm. is

$\frac{100 \text{ mm.}}{10}$ = 10 cm. long.

Or you can say that 100 mm. = 10 cm. =.1 m. They are all identical.

Let's see how to do the conversions in the measurements for mass, or weight.

If you buy a box of Tide soap powder that weighs 1.39 Kg., how many grams of powder do you have? Well, the prefix Kilo- means times 1000, so that must mean that the box contains 1.39 x 1000 grams, or 1390 grams. A pound of butter is 454 grams, which you can change to Kilograms by dividing by 1000. So, 454 grams = $\frac{454}{1000}$ Kilograms or .454 Kg.

To convert centigrams to grams, you must remember to divide by 100, since when you convert grams to centigrams, you multiply by 100. Thus, if you bought a candy bar which weighed 3350 cg., its weight in grams is $\frac{3350 \text{ cg.}}{100}$ = 33.5 g. Similarly, if your letter weighs 11 grams, it weighs 11 x 100 = 1100 cg.

Now let's look at the milligram. The cigarette package says 11 mg. of tar. That means that to find the tar content in grams, you must divide by 1000, since 1 milligram = $\frac{1}{1000}$ gram. The cigarette then contains $\frac{11}{1000}$ = .011 grams of tar. This may not seem like very much, but the U.S. Surgeon General says that it is dangerous to your health.

In the measurement of liquid volume, you will find that the most common measurement is the liter (l.) with the milliliter (ml.) being used for small quantities. The can of liquid floor wax contained 800 ml., which you can change to liters by dividing by 1000. $\frac{800 \text{ ml.}}{1000}$ = .8 l. Although the centiliter unit isn't commonly used, you could change 800 ml. to cl. by dividing by 10, or $\frac{800 \text{ ml.}}{10}$ = 80 cl.

Let's look once more at the prefixes and how they are related.

(1)	1 Km. = 1000 m.	or	1 m. = .001 Km.
	1 m. = 100 cm.	or	1 cm.= .01 m.
	1 m. = 1000 mm.	or	1 mm.= .001 m.
	1 cm. = 10 mm.	or	1 mm.= .1 cm.
(2)	1 Kg. = 1000 g.	or	1 g. = .001 Kg.
	1 g. = 100 cg.	or	1 cg. = .01 g.
	1 g. = 1000 mg.	or	1 mg. = .001 g.
	1 cg. = 10 mg.	or	1 mg. = .1 cg.
(3)	1 Kl. = 1000 l.	or	1 l. = .001 Kl.
	1 l. = 100 cl.	or	1 cl. = .01 l.
	1 l. = 1000 ml.	or	1 ml. = .001 l.
	1 cl. = 10 ml.	or	1 ml. = .1 cl.

You should see from this that the decimal form and relationship within our number system (and money system) are like that of the Metric System. Everything is in multiples of ten (10) and the prefixes are merely a code for this relationship.

Here are a few problems for you to read. Please <u>do</u> <u>not</u> fill-in the blanks, the correct answers are given in the right-hand column.

PROBLEMS	ANSWERS
1. 2.54 m. = ______ cm.	$2.54 \times 100 = 254$ cm.
2. 37 cm. = ______ m.	$37 \div 100 = .37$ m.
3. 35 mm. = ______ cm.	$85 \div 10 = 8.5$ cm.
4. 2.54 cm. = ______ mm.	$2.54 \times 10 = 25.4$ mm.
5. 3.27 Km. = ______ m.	$3.27 \times 1000 = 3270$ m.
6. 125 m. = ______ Km.	$125 \div 1000 = .125$ Km.
7. 3.2 g. = ______ mg.	$3.2 \times 1000 = 3200$ mg.
8. 227 mg. = ______ g.	$227 \div 1000 = .227$ g.
9. 73 mg. = ______ cg.	$73 \div 10 = 7.3$ cg.
10. 2.2 cg. = ______ mg.	$2.2 \times 10 = 22$ mg.
11. 800 g. = ______ Kg.	$800 \div 1000 = .8$ Kg.
12. 1.5 Kg. = ______ g.	$1.5 \times 1000 = 1500$ g.
13. 825 ml. = ______ l.	$825 \div 1000 = .825$ l.
14. 1.3 l. = ______ ml.	$1.3 \times 1000 = 1300$ ml.
15. 15 ml. = ______ cl.	$15 \div 10 = 1.5$ cl.
16. 43 cl. = ______ ml.	$43 \times 10 = 430$ ml.
17. 1273 l. = ______ Kl.	$1273 \div 1000 = 1.273$ Kl.
18. 3.4 Kl. = ______ l.	$3.4 \times 1000 = 3400$ l.

You should now be ready to try the test for this mod.

REA 446113 INTERCHANGE UNITS WITHIN THE METRIC SYSTEM

INSTRUCTIONAL MATERIALS (FORM B)

You can be one of the first ready to use the Metric System. It is easy, once you learn the new names. Don't let anyone scare you away from it, just dig in and be "one of the first".

The Metric System is really much easier to use than the English System. There are just three new names to learn: the METER, which is used for length or distance measurements; the GRAM, which is used for mass or weight measurements; and the LITER, which is used for liquid volume measurements. There are other names also, but for now, you will study only these three. To these names of measurement, are added prefixes, of which the three most commonly used are kilo-, centi-, and milli-.

For example, in measuring length, you can have a millimeter, a centimeter, a meter, or a kilometer.

It is these prefixes that make the Metric System so very easy to use. The prefixes are all related to each other by multiples of ten (10). You are already familiar with multiples of ten from our everyday counting system. Our counting or number system is a decimal system. Try your hand at adding the numbers in the following group -

hundreds	tens	units
	1	2
	2	7
		3
	8	2

Answer ________

Did you add the units column first? What number did you put in the answer for units? A 4? Right! What did you do with the left-over 10? Carried it as a 1 or as a 10 to the tens column? As a 1? Right again! Did your final answer equal 124? Good.

Our number system is a decimal system because it centers around the base 10, and the prefix deci- means 10. It takes 10-units to make 1-tens, and it takes 10-tens to make 1-hundreds.

Let's try to learn the meaning of the prefix names. First, look at the following chart

Kilo-	=	1000		
centi-	=	1/100	=	.01
milli-	=	1/1000	=	.001

The prefix Kilo- means 1000 times whatever word it is attached to. Kilowatts is probably already a familiar term to you (as on your electric bill), and 2 Kilowatts = 2000 watts. In the Metric System you can have a length of 1 Kilometer = _____ meters; you might weigh 1 Kilogram or _____ grams of meat; and you might buy 1 Kiloliter or ______ liters of fuel-oil. The capital letter K is used for Kilo- (Km., Kg., and Kl.).

The prefix centi- means 1/100 of, or .01 times whatever word it is attached to. Centi- is just like the word for penny in our money system. One cent is _____ of a dollar, or $ .01 Since you already know that it takes 100 cents to make a dollar, it should be easy to remember that ______ centimeters make 1 meter. You could say that 1 centimeter is 1/100 of a meter. One centigram is then ______ of a gram, and 1 centiliter is ______ of a liter. The small letter c is used for centi- (cm., cg., and cl.).

Finally, the prefix milli- means 1/1000 of, or .001 times the word it is attached to. Remember that some of our cigarettes are advertised as being 100 mm., or 100 millimeters long. One is even advertised as being 'a silly millimeter longer'. Actually, milli- is a very small part, and 1 millimeter is about the width of a pencil line. You will also find some of the harmful ingredients of cigarettes listed as so many milligrams of tar, nicotene, etc. This is a very small quantity by weight. Volume measurements are made in milliliters, which are sometimes also called cubic centimeters. For example, the displacement of many motorcycle engines is measured in cubic centimeters (cc.), like a 350 cc. Honda. A can of floor wax may contain 800 ml. or ______ milliliters of liquid wax. The small letter m is used for milli- (mm., mg., and ml.).

To summarize then, look at the following chart

PREFIX AND NAME	LETTERS	MEANING	
Kilometer	Km.	1000 meters	
centimeter	cm.	.01 meter	length
millimeter	mm.	.001 meter	
Kilogram	Kg.	1000 grams	
centigram	cg.	.01 gram	mass
milligram	mg.	.001 gram	
Kiloliter	Kl.	1000 liters	
centiliter	cl.	.01 liter	volume
milliliter	ml.	.001 liter	

Here are some problems of conversion within the Metric System for you to try. Conversion means change. For example, if the distance from your school to the Career Center is 5.4 Km., then the distance in meters is 5.4 x 1000 = 5400 meters.

If you live 16.5 Km. (16.5 Kilometers) from the Career Center [about 10 miles] then the distance in meters is _________ m.

Suppose you are 1.6 m. (1.6 meters) tall, how many centimeters would that be? _______ cm.

Thinking of the 100 mm. cigarette, how long would it be in cm? _________ and in m? ________

Did you get the following answers for the above questions? 16.5 Km. = 16,500 m.; 1.6 m. = 160 cm.; and 100 mm. = 10 cm. = .1 m. Good! Notice that the last answer is all multiples of ten (10). This is a good illustration of the decimal relationship in the Metric System.

Now some conversions in the measurements for mass, or weight.

If you buy a box of Tide soap powder that weighs 1.39 Kg., how many grams of powder do you have? _______ g. A pound of butter is 454 grams, which changed to Kilograms is ______ Kg. To convert centigrams to grams, you must remember to divide by 100, since when you convert grams to centigrams, you multiple by 100. If you bought a candy bar which weighs 3350 cg., its weight in grams is _________. Similarly, if your letter weighs 11 grams, it weighs _______ cg.

Now let's look at the milligram. The cigarette package says 11 mg. of tar. That means that the tar content in grams is ______ g. This might not seem like very much, but the U.S. Surgeon General says that it is dangerous to your health.

Did you get the following answers for the previous blanks?

1.39 Kg.	=	1390 g.
454 g.	=	.454 Kg.
3350 cg.	=	33.5 g.
11 g.	=	1100 cg.
11 mg.	=	.011 g.

In the measurement of liquid volume, you will find that the most common measurement is the liter (l.) and the millimeter (ml.) being used for small quantities. The can of liquid floor wax contained 800 ml., which is ______ l. Although the centiliter unit isn't commonly used, you should be able to change 800 ml. to ______ cl. by now.

Let's look once more at the prefixes and how they are related.

(1)	1 Km.	=	1000 m.	or	1 m.	=	.001 Km.
	1 m.	=	100 cm.	or	1 cm.	=	.01 m.
	1 m.	=	1000 mm.	or	1 mm.	=	.001 m.
	1 cm.	=	10 mm.	or	1 mm.	=	.1 cm.
(2)	1 Kg.	=	1000 g.	or	1 g.	=	.001 Kg.
	1 g.	=	100 cg.	or	1 cg.	=	.01 g.
	1 g.	=	1000 mg.	or	1 mg.	=	.001 g.
	1 cg.	=	10 mg.	or	1 mg.	=	.1 cg.
(3)	1 Kl.	=	1000 l.	or	1 l.	=	.001 Kl.
	1 l.	=	100 cl.	or	1 cl.	=	.01 l.
	1 l.	=	1000 ml.	or	1 ml.	=	.001 l.
	1 cl.	=	10 ml.	or	1 ml.	=	.1 cl.

You can see from this that the decimal form and relationship within our number system (and money system) are like the Metric System. Everything is in multiples of ten (10) and the prefixes are merely a code for this relationship. Another way of thinking of this relationship is that the numbers are always the same in any conversion within the Metric System, but the <u>decimal point</u> is moved about.

Here are a few problems for you to try.

1.	2.54 m.	=	______ cm.		10.	2.2 cg.	=	______ mg.
2.	37 cm.	=	______ m.		11.	800 g.	=	______ Kg.
3.	35 mm.	=	______ cm.		12.	1.5 Kg.	=	______ g.
4.	2.54 cm.	=	______ mm.		13.	825 ml.	=	______ l.
5.	3.27 Km.	=	______ m.		14.	1.3 l.	=	______ ml.
6.	125 m.	=	______ Km.		15.	15 ml.	=	______ cl.
7.	3.2 g.	=	______ mg.		16.	43 cl.	=	______ ml.
8.	227 mg.	=	______ g.		17.	1273 l.	=	______ Kl.
9.	73 mg.	=	______ cg.		18.	3.4 Kl.	=	______ l.

You may check your answers with the instructor, who has the answer list. Having completed this, you should now be ready to try the test for this mod.

REA 446111/112   INTERCHANGE UNITS IN THE METRIC AND ENGLISH SYSTEMS

INSTRUCTIONAL MATERIAL (FORM A)

In perhaps another five years almost all of our measurements will be expressed in the Metric System. The English System will be used less and less. The purpose of this mod is to help you to learn a simple way to change between the two systems.

To interchange between two systems of measurement, you must know both systems. You are already familiar with the English System. That's the yards and feet, pounds and ounces, gallons and quarts which you use now in everyday measurement. The Metric System you have learned in the previous mod (REA 446113) Instructional Material. Now let's see if you can learn a simple way to convert or interchange between the two systems.

The diagram below shows the form of how we'll convert between the two systems, in a simple way.

change within	English	change between	Metric	change within
↕	miles yards feet inches	⇄	Kilometers meters centimeters millimeters	↕

You must know how to do two things: (1) to change within the English System, and (2) to change within the Metric System.

You already have used the English System for propably ten years and should be able to change yards to feet to inches, pounds to ounces, and gallons to quarts to pints to liquid ounces. You studied changing within the Metric System in the previous mod's Instructional Material, so you should now be able to change Kilometers to meters to millimeters, Kilograms to grams to milligrams, and liters to milliliters.

What you will learn now is ONE STEP to convert between the length measurements of the two systems, ONE STEP to convert between the mass or weight measurements, and ONE STEP to convert between the liquid volumes of the two systems. Actually, these three steps all follow the same idea, so it should prove easy for you to learn.

Let's begin with the length measurements of the two systems, and learn to convert or interchange between their units. In the English System, we measure length in yards, feet and inches - oh yes, very long distances are measured in miles.

In the Metric System you should remember that we measure length in meters, centimeters, and millimeters, and the long distances in Kilometers. Look at the diagram below.

	English System	Length	Metric System	
change within ↕	miles (mi)		Kilometers (Km)	↕ change within
	yards (yd)		meters (m)	
	feet (ft)	x 2.54 →	centimeters (cm)	
	inches (in)	← ÷ 2.54	millimeters (mm)	

Notice the arrows between the two systems - they indicate how you can simply change between the two systems. A length measured in INCHES can be changed to a length in centimeters by multiplying the number of inches by 2.54. To go the other way, a length in CENTIMETERS can be changed to a length in inches by dividing the number of centimeters by 2.54.

For example, this page is 11 inches long which in centimeters is:
11 x 2.54 =

```
     11
 x 2.54
 ------
     44
    55
   22
 ------
  27.94 cm (or almost 28 centimeters)
```

If you measured the width of this paper as 21 centimeters and you wanted to know how wide it is in inches, you would divide the 21 centimeters by 2.54.

```
          8.26 in (or about 8¼ inches)
2.54 ) 21.00.00
       2032
         68 0
         50 8
         17 20
         15 24
          1 96
```

Let's see how tall you are in meters if your height is 5 feet, 8 inches.

In order to use the simple conversion you must do three steps:

1) Change within the English System - so that the height is expressed all in inches.
2) Change between the English and the Metric Systems - so that the inches are converted to centimeters.
3) Change within the Metric System - so that your height is all in meters.

Step 1 5 ft 8 in = _____ inches (5 ft x 12 in/ft + 8 in = ___)

```
   5
x 12
----
  10
 5
----
 60 in + 8 in = 68 inches
```

Step 2   68 in = ______ cm   (68 in x 2.54 cm/in = ____)

```
     68
   x 2.54
   ------
     2 72
    32 0
   136
   ------
   170.72 cm   (or about 171 centimeters)
```

Step 3   171 cm = ______ m   (171 cm ÷ 100 cm/m = ____)

```
          1.71 m   (or about 1.7 meters)
    100 / 171.00
          100
          ---
           71 0
           70 0
           ----
            1 00
            1 00
            ----
```

If you wanted to go in reverse, from meters to feet, you would do the steps backwards. Follow the steps in the following problem.

An olympic size swimming pool is 25 meters long, how many feet is this?

Step 3   25 m = _____ cm   (25 m x 100 cm/m = _____)

```
     25
   x 100
   -----
     00
    00
   25
   -----
   2500 cm   (2500 centimeters)
```

Step 2   2500 cm = _____ in   (2500 cm ÷ 2.54 cm/in = _____)

```
              9 84.2   in   (or about 984 inches)
    2.54^/2500.00^0
          2286
          ----
           214 0
           203 2
           -----
            10 80
            10 16
            -----
               64 0
               50 8
               ----
               13 2
```

Step 1   984 in = _____ ft   (984 in ÷ 12 ft/in = _____)

```
           82.   ft   (or 82 feet = the length of the pool)
    12 / 984.
         96
         --
          24
          24
          --
```

You will find this simple method works well for any length conversion between the Metric and English Systems. Just REMEMBER the steps, and the number 2.54 that you use to multiply or divide with.

Try one more. A new pencil measures 7.5 inches. How long would this be in millimeters?

Step 1 7.5 in (no change needed here - the measurement is in inches)

Step 2 7.5 in = ____ cm

7.5 in x 2.54 in/cm = 19.05 cm (or about 19 centimeters)

Step 3 19 cm = _____ mm

19 cm x 10 mm/cm = 190 mm (The pencil is 190 millimeters)

OK, you say - I've got it; but what if I want to figure the distance from my home to the Career Center in Kilometers. I know the distance in miles is 13.3 mi. Do I first have to change all the miles to inches? How many inches is there in a mile anyway? The answer is - you could. Remember there are 5280 feet in a mile, and 12 inches in one foot. There is an easier way to do this though - if you will memorize the following:

a) ___ miles x 1.6 = ___ Kilometers.

b) ___ Kilometers ÷ 1.6 = ___ miles.

Thus, for this conversion, you have to remember the number 1.6. Let's try your problem of the distance of 13.3 miles from your home to the Career Center -

13.3 mi x 1.6 Km/mi = ____ Km.

```
  13.3
 x 1.6
  79 8
 133
 21.28 Km  (or slightly more than 21 Kilometers)
```

The distance from Lansing to Chicago is 340 Km. How far is this in miles?

340 Km ÷ 1.6 mi/Km = ____ mi

```
         21 2.5 mi  (or about 213 miles is the distance)
 1.6^/ 340.0^0
       32
        20
        16
         4 0
         3 2
           8 0
           8 0
```

Take a look at the one step conversion between the mass or weight measurements.

In the English System, we measure mass in pounds and ounces, while in the Metric System you should remember that we measure mass in milligrams, grams, and Kilograms - and sometimes in centigrams.

Look at the diagram below:

English System	Mass or Weight	Metric System
Pounds (lbs)	x 28.3 →	Kilograms (Kg)
Ounces (oz)	← ÷ 28.3	grams (gm)
		centigrams (cg)
		milligrams (mg)

Notice the arrows between the two systems. They indicate how you can easily change between the two systems. A mass measured in ounces can be changed to a mass in grams by multiplying the number of ounces by 28.3. To go the other way, a mass in grams can be changed to a mass in ounces by dividing the number of grams by 28.3.

For example, a 6-ounce jar of instant coffee weighs

6 oz x 28.3 g/oz = ____ grams

```
      6
  x 28.3
     1 8
    48
   12
   169.8 gm  (or about 170 grams)
```

If you weighed the jar and the coffee on a scale and found that its mass is 250 grams, then its mass in the English System would be

250 gm ÷ 28.3 g/oz = ____ ounces

```
               9.39 oz  (or almost 9.4 ounces)
28.3^/ 250.0^00
       238 7
        11 3 0
         8 4 9
         2 8 10
         2 5 47
           2 63
```

Let's try the following: A 3 pound 4 ounce (3 lb, 4 oz) box of soap powder weighs how many Kilograms?

To do this conversion, you must use the three steps:

Step 1 Change within the English System so that the mass is all in ounces.

3 lb 4 oz = ____ oz

(3 lb x 16 oz/lb) + 4 oz =

48 oz + 4 oz = 52 ounces

Step 2 Change between the English and Metric Systems so that the ounces are converted to grams.

52 oz = ____ gm

52 oz x 28.3 g/oz = ____ grams

```
      52
  x 28.3
  ------
    15 6
   416
  104
  ------
  1471.6 gm   (or about 1472 grams)
```

Step 3 Change within the Metric System so that the mass is in Kilometers.

1472 gm = ____ Kg

1472 gm ÷ 1000 g/Kg = ____ Kilograms

```
            1.472 Kg  (or about 1.5 Kilograms is the
1000 / 1472.000        weight of the box of soap powder)
       1000
        472 0
        400 0
         72 00
         70 00
          2 000
          2 000
```

If you wanted to know how many pounds there are in 5 Kilograms, you would do the steps in reverse order.

Step 3 5 Kg = ____ gm

5 Kg x 1000 g/Kg = ____ gm

```
      5
 x 1000
 ------
      0
     0
    0
   5
 ------
   5000 gm
```

Step 2 5000 gm = ____ oz

5000 gm ÷ 28.3 g/oz = ____ oz

```
          17 6.67 oz   (or about 177 ounces)
28.3^/ 5000.0^00
       283
       2170
       1981
        1890
        1698
         192 0
         169 8
          22 20
          19 81
           2 39
```

Step 1 177 oz = ____ lb

177 oz ÷ 16 oz/lb = ____ lb

```
      11.06 lb   (or about 11 pounds)
16/ 177.00
    16
     17
     16
      1 00
        96
         4
```

You should find this simple method will work well for almost any mass or weight conversion between the English and the Metric Systems. Just REMEMBER the steps, and the number 28.3 that you use to multiply or divide with.

Try another mass conversion problem. A box of table salt contains 1 pound, 10 ounces (1 lb, 10 oz). What is the weight in grams?

Step 1 1 lb 10 oz = ____ oz

(1 lb x 16 oz/lb) + 10 oz = ____ oz

16 oz + 10 oz = 26 oz

Step 2 26 oz = ____ gm

26 oz x 28.3 g/oz = ____ gm

```
    26
 x 28.3
    7 8
  208
  52
  735.8 gm    (or about 736 grams)
```

Step 3 Since the answer we wanted was to be in grams, you need do no further conversion.
The answer is that the box of salt weighs 736 grams.

Last, let's take a look at the one-step conversion between the liquid volume measurements.

In the English System, we measure the liquid volume in fluid ounces, pints, quarts and gallons. In the Metric System you will measure liquid volume in milliliters, (sometimes centiliters), liters, and Kiloliters.

Look at the diagram below for the conversions.

English System	Liquid Volume	Metric System
gallons (gal)	x .96 →	Kiloliters (Kl)
quarts (qt)		liters (l)
pints (pt)	← ÷ .96	centiliters (cl)
fluid ounces (fl oz)		milliliters (ml)

Notice the arrows between the two systems. They indicate how you can easily change between the two systems. A liquid volume measured in quarts can be simply changed to a volume in liters by multiplying the number of quarts by .96. To go the other way, a liquid volume measured in liters can be changed to a volume in quarts by dividing the number of liters by .96.

For example, 2 quarts of milk would be equal to 2 x .96 = ____ liters.

```
     2
 x .96
 -----
    12
   1 8
 -----
  1.92 l   (or about 1.9 liters of milk)
```

If you had 4 liters of motor oil in a container, you would have

4 ÷ .96 = ____ qt

```
         4.16 qt    (or about 4.2 quarts of oil)
.96^/ 4.00^00
      384
      ----
       16 0
        9 6
       ----
        6 40
        5 76
        ----
          64
```

Let's try the following: A 1.5 gallon container of liquid bleach equals how many liters of bleach?

Again, to do this type of conversion, you must use the three steps.

Step 1 Change within the English System, so that you'll have the liquid volume all in quarts.

1.5 gal = ____ qt

1.5 gal x 4 qt/gal = ____ qt

$$\begin{array}{r} 1.5 \\ \times\ 4 \\ \hline 6.0 \end{array}\ \text{qt}$$

Step 2 Change between the English and the Metric Systems so that the quarts are converted to liters.

6 qt = ____ l

6 qt x .96 l/qt = ____ l

$$\begin{array}{r} 6 \\ \times\ .96 \\ \hline 36 \\ 5\ 4 \\ \hline 5.76 \end{array}\ \text{l} \quad \text{(or about 5.8 liters)}$$

Step 3 Change within the Metric System. Since you wanted your answer in liters, no further conversion is needed. The answer is that the container has 5.8 liters of bleach.

If you wanted to know how many fluid ounces there are in a 59 milliliter bottle of ink, you would have to do the steps in reverse order.

Step 3 59 ml = ____ l

59 ml ÷ 1000 ml/l = ____ l

```
        .059 l   (.059 liter)
1000 / 59.000
       50 00
        9 000
        9 000
```

Step 2 .059 l = ____ qt

.059 l ÷ .96 l/qt = ____ qt

```
          .061 qt  (or about .06 quart)
.96^/  .05^900
         5 76
           140
            96
            44
```

Step 1 .06 qt = ____ fl oz

.06 qt x 32 oz/qt = ____ fl oz

```
   .06
 x 32
   12
  18
  1.92 fl oz   (or about 1.9 fluid ounces of ink)
```

You should find this simple method will work very well for almost any liquid volume conversion. Just REMMEMBER the steps, and the number .96 that you use to multiply or divide with.

Try another liquid volume conversion problem. A can of spray cleaner contains 1 pint, 6 ounces of cleaner - How many liters does it contain?

Step 1 1 pt 6 oz = ____ qt

(1 pt x 16 oz/pt) + 6 oz = ____ fl oz (convert all to ounces)
16 oz + 6 oz = 22 fl oz

22 oz ÷ 32 oz/qt = ____ qt (then convert to quarts)

```
        .687 qt   (or about .69 quart)
32 / 22.000
     19 2
      2 80
      2 56
        240
        224
         16
```

Step 2 .69 qt = ____ l

.69 qt x .96 l/qt = ____ l

```
    .69
  x .96
    414
   621
  .6624 l   (or about .66 liters)
```

Step 3 Since the answer to step 2 is already in liters, our answer is that the can contains .66 liters of cleaner.

Suppose you had wanted to know how many milliliters the 1 pint, 6 ounce can of spray cleaner contained. You would then do the following:

Step 3 .66 l x 1000 ml/l = ____ ml

```
     .66
  x 1000
  660.00 ml  (or the can contains 660 milliliters)
```

You now have all the information you will need to convert between the English System and the Metric System. This learning packet should have shown you how to:

1) Convert in the English System by first changing all units to one of the common units of measurement - the inch (or the mile), the ounce, or the quart.

2) Convert between the English and the Metric by remembering only four numbers - 2.54 for length (1.6 for long lengths), 28.3 for mass or weight and .96 for liquid volume. AND remember to <u>multiply</u> if you are going from English to Metric, or to <u>divide</u> if you are going from Metric to English.

3) Convert in the Metric System by first changing all units to one of the three common units of measurement - the centimeter, the gram, or the liter.

Don't forget that changing within the Metric System is simply a matter of moving the decimal point.

Here are a few problems for you to read. Please <u>do not</u> fill in the blanks, the correct answers are given in the right-hand column.

Problems	Answers
1. 3 ft = ____ m	3 ft x 12 ft/in = 36 in 36 in x 2.54 cm/in = 91.4 cm 91 cm ÷ 100 cm/m = <u>.91 m</u>
2. 2.3 m = ___ ft ___ in	2.3 m x 100 cm/m = 230 cm 230 cm ÷ 2.54 cm/in = 90.5 in 90.5 in ÷ 12 in/ft = <u>7 ft 7 in</u>
3. 7 in = ____ mm	7 in x 2.54 cm/in = 17.8 cm 17.8 cm x 10 mm/cm = <u>178 mm</u>
4. 100 mm = ____ in	100 mm ÷ 10 mm/cm = 10 cm 10 cm ÷ 2.54 cm/in = <u>3.9 in</u>
5. 25 mi = ____ Km	25 mi x 1.6 Km/mi = <u>40 Km</u>
6. 100 Km = ____ mi	100 Km ÷ 1.6 Km/mi = <u>62.5 mi</u>
7. 3200 mg = ____ oz	3200 mg ÷ 1000 mg/g = 3.2 gm 3.2 gm ÷ 28.3 g/oz = <u>.1 oz</u>
8. .5 oz = ____ mg	.5 oz x 28.3 g/oz = 1.415 gm 1.415 gm x 1000 mg/gm = <u>1415 mg</u>

9. .8 Kg = ____ lb	.8 Kg x 1000 g/Kg = 800 gm 800 gm ÷ 28.3 g/oz = 28.25 oz 28.3 oz ÷ 16 oz/lb = <u>1.9 lb</u>
10. 160 lb = ____ Kg	160 lb x 16 oz/lb = 2560 oz 2560 oz x 28.3 g/oz = 72440 gm 72440 gm ÷ 1000 g/Kg = <u>72.4 Kg</u>
11. 5 lb 6 oz = ____ Kg	(5 lb x 16 oz/lb) + 6 oz = 86 oz 86 oz x 28.3 g/oz = 2433.8 gm 2434 gm ÷ 1000 g/Kg = <u>2.4 Kg</u>
12. 227 cg = ____ oz	227 cg ÷ 100 cg/g = 2.27 gm 2.27 gm ÷ 28.3 g/oz = <u>.08 oz</u>
13. 825 ml = ____ qt	825 ml ÷ 1000 ml/l = .825 l .825 l ÷ .96 l/qt = <u>.86 qt</u>
14. 1 gal 2 qt = ____ ml	(1 gal x 4 qt/gal) + 2 qt = 6 qt 6 qt x .96 l/qt = 5.76 l 5.76 l x 1000 ml/l = <u>5760 ml</u>
15. 1 qt 1 pt = ____ l	1 qt + (1 pt ÷ 2pt/qt) = 1.5 qt 1.5 qt x .96 l/qt = <u>1.44 l</u>
16. 3 l = ____ pt	3 l ÷ .96 l/qt = 3.1 qt 3.1 qt x 2 pt/qt = <u>6.2 pt</u>
17. 50 Kl = ____ gal	50 Kl x 1000 Kl/l = 50,000 l 50,000 l ÷ .96 l/qt = 52,083 qt 52,083 qt ÷ 4 qt/gal = <u>13,020 gal</u>
18. 10,000 gal = ____ Kl	10,000 gal x 4 qt/gal = 40,000 qt 40,000 qt x .96 l/qt = 38,400 l 38,400 l ÷ 1000 l/Kl = <u>38.4 Kl</u>

You should now be ready to try the test for this mod.

REA 446111/112 INTERCHANGE UNITS IN THE METRIC AND ENGLISH SYSTEMS

INSTRUCTIONAL MATERIAL (FORM B)

In perhaps another five years almost all of our measurements will be expressed in the Metric System. The English System will be used less and less. The purpose of this mod is to help you to learn a simple way to change between the two systems.

To interchange between two systems of measurement, you must know both systems. You are already familiar with the English System. That's the yards and feet, pounds and ounces, gallons and quarts which you use now in everyday measurement. The Metric System you have learned in the previous mod (REA 446113) Instructional Material. Now let's see if you can learn a simple way to convert or interchange between the two systems.

The diagram below shows the form of how we'll convert between the two systems, in a simple way.

change within	English		Metric	change within
↕	miles		Kilometers	↕
	yards	change	meters	
	feet	⟷ between	centimeters	
	inches		millimeters	

You must know how to do two things: (1) to change within the English System, and (2) to change within the Metric System.

You already have used the English System for probably ten years and should be able to change yards to feet to inches, pounds to ounces, and gallons to quarts to pints to liquid ounces. You studied changing within the Metric System in the previous mod's Instructional Material, so you should now be able to change Kilometers to meters to millimeters, Kilograms to grams to milligrams, and liters to milliliters.

What you will now learn is ONE STEP to convert between the length measurements of the two systems, ONE STEP to convert between the mass or weight measurements, and ONE STEP to convert between the liquid volumes of the two systems. Actually, these three steps all follow the same idea, so it should prove easy for you to learn.

Let's begin with the length measurements of the two systems, and learn to convert or interchange between their units. In the English System, we measure length in yards, feet and inches - oh yes, very long distances are measured in miles.

In the Metric System you should remember that we measure length in meters, centimeters, and millimeters, and the long distances in Kilometers.

Look at the diagram below.

change within	English System	Length	Metric System	change within
	miles (mi)		Kilometers (Km)	
	yards (yd)		meters (m)	
	feet (ft)	x 2.54	centimeters (cm)	
	inches (in)	÷ 2.54	millimeters (mm)	

Did you notice the arrows between the two systems? They indicate how you can simply change between the two systems. Notice that a length in inches can be changed to a length in centimeters by multiplying the number of inches by 2.54. To go the other way, a length in CENTIMETERS can be changed to a length in inches by dividing the number of centimeters by 2.54.

For example, this page is 11 inches long which in centimeters is:

11 in x 2.54 cm/in = 27.94 cm (or almost 28 centimeters)

If you measured the width of this paper as 21 centimeters and you wanted to know how wide it is in inches, you would divide -

21 cm ÷ 2.54 cm/in = ____________________.

Did you get 8.26 in, or about 8¼ inches? Good.

Let's see how tall you are in meters if your height is 5 feet, 8 inches.

In order to use the simple conversion you must do three steps:

1) Change within the English System - so that the height is expressed all in inches.
2) Change between the English and the Metric Systems - so that the inches are converted to centimeters.
3) Change within the Metric System - so that your height is all in meters.

Now, you try the steps -

Step 1 5 ft 8 in = ------ in
(5ft x 12 in/ft) + 8 in = ______ inches

Step 2 ______ in = ------ cm
______ in x 2.54 cm/in = ______ centimeters

Step 3 ______ cm = ------ m
______ cm ÷ 100 cm/m = ______ meters

If your answers agree roughly with the following, you did it right.
(68 inches, 171 centimeters, 1.7 meters)

If you wanted to go from meters to feet, you would do the steps in reverse order. For example, how many feet long is an olympic size swimming pool of 25 meters?

Step 3 25 m = ------ cm
25 m x 100 cm/m = _______ centimeters

Step 2 _____ cm = ------ in
_____ cm ÷ 2.54 cm/in = ______ inches

Step 1 _____ in = ------- ft
_____ in ÷ 12 in/ft = _______ feet

Again, if your answers about agree with the following, you are doing the problem correctly. (2500 centimeters, 984 inches, 82 feet) The 25-meter swimming pool is about 82-feet long.

You will find that this simple method works well for any length conversion between the Metric and English Systems. Just REMEMBER the steps, and the number 2.54 that you use to multiply or divide with.

Try this one. A new pencil measures 7.5 inches. How long would it be in millimeters?

Step 1 7.5 in = ------ inches

Step 2 _____ in x 2.54 in/cm = ------centimeters

Step 3 _____ cm ÷ 100 cm/m = _______ millimeters

Did you find that your answers to the three steps were 7.5 inches, 19 centimeters, and 190 millimeters? These are about the correct answers if rounded off to the nearest centimeter.

Got it? Good! What if you wanted to find the distance from your home to the Career Center in Kilometers? Say that the distance is 13.3 miles in the English System. You could change the miles to inches as we did above! Remember - 5280 feet per mile, and 12 inches per foot? It would make quite a few inches. There is an easier way to handle long distances, just memorize the following:

a) _____ miles x 1.6 = _____ Kilometers

b) _____ Kilometers ÷ 1.6 = _____ miles

Let's try the problem about the distance to the Career Center now.

13.3 x 1.6 Km/mi = ______ Kilometers

If you got the answer of a little more than 21 Kilometers, you did it right. Try the following problem which is the reverse.

How many miles is it to Chicago from Lansing, if the distance is 340 Km?

340 Km ÷ 1.6 Km/mi = _______ miles

Did you get an answer of about 213 miles as the distance from Chicago to Lansing? Great. You have been doing things right so far. Now take a look at the one-step conversion between the mass or weight measurements.

In the English System, we measure mass in pounds and ounces, while in the Metric System you should remember that we measure mass in milligrams, grams, and Kilograms - and sometimes in centigrams.

Look at the diagram below:

English System	Mass or Weight	Metric System
pounds (lb)	x 28.3 →	Kilograms (Kg)
ounces (oz)	← ÷ 28.3	grams (gm)
		centigrams
		milligrams

Did you notice the arrows between the two systems? They indicate how you can easily change between the two systems. Notice that a mass measured in ounces can be changed to a mass in grams by multiplying by 28.3. To go the other way, a mass measured in grams can be changed to a weight in ounces by dividing the number of grams by 28.3.

Try this example problem. A 6-ounce jar of instant coffee weighs ___ gm?

6 oz x 28.3 g/oz = ______ grams

If you multiplied correctly, and rounded-up to the nearest gram, you should have gotten an answer of 170 grams. Agree? Suppose you weighed the jar and contents on a scale and it was 250 grams, - how many ounces would this be?

250 gm ÷ 28.3 g/oz = _______ ounces

This time did you get 9.4 ounces, after dividing correctly and rounding-up? Very good.

Now let's try the following problem. A 3 pound, 4 ounce (3 lb 4 oz) box of soap powder weighs how many Kilograms?

To do this, remember the three steps that you used before. Use them again in this problem.

Step 1 Change within the English System.
3 lb 4 oz = ------ oz
(3 lb x 16 oz/lb) + 4 oz = ______ ounces

Step 2 Change between the English and Metric Systems.
______ oz = ------ gm
______ oz x 28.3 g/oz = ______ grams

Step 3 Change within the Metric System.
______ gm = ______ Kg
______ gm ÷ 1000 g/Kg = ______ Kilograms

Do your answers agree roughly with the following? (52 ounces, 1472 grams, 1.5 Kilograms) If so, you've done it correctly again!

Suppose you wanted to know how many pounds there are in 5 Kilograms. What would you do? The steps in reverse order? Right on.

Step 3 5 Kg = ------ gm
5 Kg x 1000 g/Kg = ______ grams

Step 2 ______ gm = ------ oz
______ gm ÷ 28.3 g/oz = ______ ounces

Step 3 ______ oz = ------ lb
______ oz ÷ 16 oz/lb = ______ pounds

The answers to these three steps are: 5000 grams, 177 ounces, and 11 pounds. Do your answers agree? They should, if you remembered to round-up on the ounces, and to round-off on the pounds.

You should find that this simple method will work well for almost any mass or weight conversion between the English and the Metric Systems. Just REMEMBER the steps, and the number 28.3 that you use to multiply or divide with.

Try another mass conversion problem. A box of table salt contains 1 pound, 10 ounces (1 lb, 10 oz). What is the weight in grams?

Step 1 1 lb 10 oz = ------ oz
(1 lb x 16 oz/lb) + 10 oz = ______ ounces

Step 2 ______ oz = ------ gm
______ oz x 28.3 g/oz = ______ grams

Step 3 ______ gm = ------ gm

Since the answer to step 2 is already in grams, you have no work to do in step 3. Did you get the following answers? (26 ounces, 736 grams, 736 gm) Very good for you.

Lastly, take a look at the one-step conversion between the liquid volume measurements.

In the English System, we measure the liquid volume in fluid ounces, pints, quarts, and gallons. In the Metric System you will measure liquid volume in milliliters, (sometimes centiliters), liters, and Kiloliters.

Look at the diagram below for the conversions.

English System	Liquid Volume	Metric System
gallons (gal)		Kiloliters (Kl)
quarts (qt)	x .96 →	liters (l)
pints (pt)	← ÷ .96	centiliters (cl)
fluid ounces (fl oz)		milliliters (ml)

Did you <u>notice</u> <u>the</u> <u>arrows</u> between the two systems? They indicate how you can easily change between the two systems. A liquid volume measured in quarts can be simply changed to a volume in liters by <u>multiplying</u> the number of quarts by <u>.96</u>. To go the other way, a liquid volume measured in liters can be changed to a volume in quarts by <u>dividing</u> the number of liters by <u>.96</u>.

For example, 2 quarts of milk would be how many liters?

2 qt x .96 l/qt = ______ liters

If you had 4 liters of motor oil in a container, how many quarts do you have?

4 l ÷ .96 l/qt = ______ quarts

Do your answers agree with the following? If you rounded-off in the first problem, you should have 1.9 liters of milk; and by rounding-up in the second problem, you should have 4.2 quarts.

Now try this problem. A 1.5 gallon liquid bleach container holds how many liters of bleach? To do this conversion, use the three steps.

Step 1 Change within the English System.
1.5 gal = ------ qt
1.5 gal x 4 qt/gal = ______ quarts

Step 2 Change between the English and Metric Systems.
______ qt = ------ l
______ qt x .96 l/qt = ______ liters

Step 3 Change within the Metric System.

Since the answer in step 2 is already in liters, you didn't have to do anything in step 3. Were your answers to steps 1 and 2 as follows? 6 quarts, 5.8 liters

Suppose you had 59 milliliters of ink in a bottle, how many fluid ounces would this be? Do this problem by doing the steps in reverse order again.

Step 3 59 ml = ------ l
59 ml ÷ 1000 ml/l = ______ liters

Step 2 ______ l = ------ qt
______ l ÷ .96 l/qt = ______ quarts

Step 1 ______ qt = ------ fl oz
______ qt x 32 oz/qt = ______ fluid ounces

Doing the dividing and multiplying correctly, did you get .059 liters, .06 quarts, and 1.9 fluid ounces? You should have rounded-off your answers to steps 2 and 1. Agreed? Good.

You should find that this simple method will work very well for almost any liquid volume conversion. Just REMEMBER the steps, and the number .96 that you use to multiply or divide with.

Now try another liquid volume conversion problem. A can of spray cleaner contains 1 pint 6 ounces of cleaner. How many liters is this?

Step 1 1 pt 6 oz = ------ qt
(1 pt x 16 oz/pt + 6 oz = ______ quarts

Step 2 ______ qt = ------ l
______ qt x .96 l/qt = ______ liters

Step 3 ______ l = ------ liters (The answer is the same as that of step 2)

Did you remember to round-up on the quarts? You should have .69 quarts. Did you round-off the liters? Did you get .66 liters? Very good. Now suppose that you had wanted the answer to be in milliliters - would the answer to step 3 be 660 milliliters? The change within the Metric System would require you to do the following:

.66 l x 1000 ml/l = ______ milliliters

You now have all the information you will need to convert between the English and the Metric Systems. This learning packet should have helped you to learn

1) To convert within the English System by first changing all units to one of the three common units of measurement - for length it is the ______ (or the ________ for long lengths), for mass or weight it is the ______, and for liquid volume it is the ______. Did you answer inch, (mile), ounce and quart? Very good.

2) To convert between the English and the Metric Systems, you only need to remember four numbers. Can you recall them?
_______ for length, (or _____ for long distances),
_______ for mass or weight, and ______ for liquid volume.

Think a minute, these numbers you really should remember to be able to change between the two systems with ease. They are 2.54, (1.6), 28.3 and .96. All correct? Hey, nice going.

3) To convert within the Metric System, first change all units to one of the common units of measurement - for length it is the ______ (or the ______ for long lengths), for mass or weight it is the ______, and for liquid volume it is the _______.

It should be easy for you by now to fill in the last few blanks with the correct answers - centimeters are for length (or Kilometers for long distances), the gram is used for mass or weight measurements, and for liquid volume measurements you use the liter.

You should now be able to convert easily between the English and the Metric Systems of measurement!

Here are a few problems for you to try.

1. 3 ft = ________ m
2. 2.3 m = _____ ft ____ in
3. 7 in = ________ mm
4. 100 mm = ________ in
5. 25 mi = ________ Km
6. 100 Km = ________ mi
7. 3200 mg = ________ oz
8. .5 oz = ________ mg
9. .8 Kg = ________ lb
10. 160 lb = ________ Kg
11. 5 lb 6 oz = ________ Kg
12. 227 cg = ________ oz
13. 825 ml = ________ qt
14. 1 gal 2 qt = ________ ml
15. 1 qt 1 pt = ________ l
16. 3 l = ________ pt
17. 50 Kl = ________ gal
18. 10,000 gal = ________ Kl

You may check your answers with the instructor, who has the answer list.

Having completed this, you should now be ready to try the test for this mod.

REA 446113 INTERCHANGE UNITS WITHIN THE METRIC SYSTEM

INSTRUCTIONS: You should do all ten problems on this post-test. After having studied the learning materials for this mod, you will probably find it easy to do. Work the problems on this paper. Place your answer on the blank line in the problem. Please fill-in the starting time ____________ and your stopping time ______________.

____
NAME

____
SOCIAL SECURITY #

1. Your height of 165 cm = _________ m tall.

2. A small amount of salt weighs 2.3 gm = ________ mg as mass on a balance.

3. A fuel oil tank contains 2.2 Kl = _________ l in volume.

4. A distance of 16,500 m = ______ Km from home to the Career Center.

5. A cigarette measuring 100 mm = _________ cm in length.

6. A can of pop contains 360 ml = _________ cl of soda pop.

7. If your weight is 61 Kg = _________ gm is your mass.

8. A package of sliced lunch meat is 750 gm = _________ Kg in weight.

9. Use 125 ml = ________ l of motor oil for each liter of gasoline in a 2-cycle engine.

10. A closet door is 2.1 m = _________ cm high.

REA 446111/112   INTERCHANGE UNITS IN THE METRIC & ENGLISH SYSTEMS

INSTRUCTIONS: You should do all ten problems on this post-test. After having studied the learning materials for this mod, you will probably find it very easy. Work the problems on this paper. Place your answer on the blank line in the problem. Please fill-in your starting time ________ & stopping time ________.

____
NAME

____
SOCIAL SECURITY #

1. The length of 4 ft 10 in = _________ m long.

2. A speed of 55 mi per hour = _________ Km per hour.

3. A can of coffee weighs 2 lb = _________ Kg of coffee.

4. A fill-up of gasoline is 9.5 gal = _________ l of gasoline.

5. A short line length is 42 mm = _________ in long.

6. A bottle of rubbing alcohol contains 3 pt = ______ ml of alcohol.

7. A tank for fuel oil holds 850 gal = _________ Kl of oil.

8. If your mass is 61 Kg = ________ lb is your weight in pounds.

9. A wedding ring has 283 mg = _________ oz of gold in it.

10. A speed limit of 40 Km per hour = _________ mi per hour.

APPENDIX B

LEARNING ACTIVITIES OPINIONNAIRE

APPENDIX B

LEARNING ACTIVITIES OPINIONNAIRE

The following survey form describes various activities that you may use in learning skills and knowledges. Some of these activities may be of more value to you than other activities. What we want you to think about is "how" you are best able to learn. What things motivate you to learn and while learning, what activities prove valuable to you.

This is not an evaluation of the class you are presently in, but an attempt to determine which learning activities are best suited to you as an individual. When you read these statements, think about all of the classes you have taken and the learning activities that proved valuable to you.

Name ______________________ Date ________ Age ___ Sex ________
LAST FIRST MIDDLE

Birthdate ______________ School ____________ City _____________

Grade ________ Program ____

Used with permission from John C. Banks, Center for Vocational, Technical, and Adult Education, University of Wisconsin-Stout, Menomonie, Wisconsin.

DIRECTIONS: Below is a list of different things that you can do to learn skills and knowledges. Read each statement carefully. Think about how much the activity helps you to learn. Show your reaction according to the following scale:

__ Of no value __ Somewhat valuable __ Average value

__ Very valuable __ Extremely valuable

Put an X in the square that best fits your response. The way you answer these statements will not affect your school marks in any way. There are no right or wrong answers. The answers apply only to what is best for you.

		Of no value	Somewhat valuable	Average value	Very valuable	Extremely valuable
1. Working with tools, equipment, apparatus & materials.	1					
2. Working and meeting with individuals or groups of people to learn new information and ideas.	2					
3. Activities involving the use of scale models, devices, and simulated situations. (Role playing, driver training simulator, games).	3					
4. Activities that teach job skills.	4					
5. Learning activities in which information and skills are presented by television, teacher or a classmate.	5					
6. Activities that allow me to immediately apply what I learn to actual problems that I face.	6					
7. Learning experiences that only require me to listen to learn new information.	7					
8. Instruction using media (films, tapes, slides) to pictorially and graphically describe events, skills and procedures.	8					
9. Instruction dealing with formulas and symbols which describe the knowledges to be learned.	9					
10. Instruction based mainly on reading.	10					
11. Written or oral instruction presented by a teacher with support of films, slides, and tapes.	11					

		Of no value	Somewhat valuable	Average value	Very valuable	Extremely valuable
12. Classes where everything is set up, allowing me no choice in determining goals or objectives.	12					
13. Teacher-organized instruction where I have little influence on the type of instructional material and learning activities used.	13					
14. Class situations that lead me from simple to complex learning activities with pre-determined goals, objectives and sequence.	14					
15. Working alone but with constant teacher-supervision and organization.	15					
16. Organized situations, from simple to complex, which give me a choice of where I want to start, stop, or branch out to new experiences.	16					
17. Learning activities that have no pre-set goals, you just set your own goals and do what you want.	17					
18. Working alone and setting my own pace, determining my own goals and objectives.	18					
19. Courses that allow me to establish my own learning sequence and activities.	19					
20. Student designed and directed instructional activities.	20					
21. Classes involving a minimum amount of organization.	21					
22. Instruction organized completely by me.	22					

APPENDIX C

LEARNING ACTIVITIES SURVEY

APPENDIX C

LEARNING ACTIVITIES SURVEY

Please print the following information -

Name ______________________________________ Date ____________
LAST *FIRST* *MIDDLE*

Age __________ Sex _________ Birthdate ____________________________
MONTH *DAY* *YEAR*

Home School ________________ Grade _____ CACC Program ________________

What follows is a list of different things you can do (activities) that may help you to learn skills or to know things. Some of these activities may have more value or meaning to you than others. What you should think about when checking this form is "how" you feel you best learn. What things make you want to learn, and while learning, what sort of activities are valuable to you.

The survey is a list of choices. There are no right or wrong answers. Answer all of the questions as well as you can. Your answers will have no effect on your grades in school or on your studies here at the Career Center.

THIS IS NOT A MEASURE OF THE PROGRAM (CLASS) THAT YOU ARE NOW ATTENDING AT THE CAREER CENTER. We are trying to find out which kind of learning activities are best suited to you as a person. When you read the list, think about all of the classes that you have taken and about those things which you did that helped you to learn.

Remember, the survey is about you and you alone. It is not a survey of what you can do, but of what you feel (value) is the easiest way for you to learn.

Adapted with permission from John C. Banks' Learning Activities Opinionnaire.

LEARNING ACTIVITIES SURVEY

DIRECTIONS: Below is a list of different things that you can do (activities) to learn skills. Read each sentence carefully. Think about how much the activity helps you to learn. Put an "X" in the square under the value that best fits your feelings. You will have a choice of the following -

- Of no value
- Somewhat valuable
- Average value
- Very valuable
- Extremely valuable

		Of no value	Somewhat valuable	Average value	Very valuable	Extremely valuable
1. Working with tools, equipment and materials.	1.					
2. Working and meeting with one or more other people to learn new information and ideas.	2.					
3. Activities using scale models, machines, or make-believe (like games or acting).	3.					
4. Activities that teach job skills.	4.					
5. Learning activities in which information and skills are given by television, teacher or classmate.	5.					
6. Activities that allow me to immediately apply what I learn to actual problems that I face.	6.					
7. Learning experiences that only require me to listen to learn new information.	7.					
8. Instruction using films, tapes, or slides to show by pictures or graphs the event or skill.	8.					
9. Instruction using formulas and symbols which describe the things to be learned.	9.					
10. Instruction using mostly reading.	10.					
11. Written or oral instruction given by a teacher and using films, slides, and tapes.	11.					

		Of no value	Somewhat valuable	Average value	Very valuable	Extremely valuable
12. A course in which everything is planned, allowing me no say in the goals or objectives.	12.					
13. Instruction where I have little to say about the learning materials or things we do.	13.					
14. Class conditions that lead me from simple to complex activities which have planned goals, objectives and steps to follow.	14.					
15. Working alone but with the teacher always nearby to supervise and direct.	15.					
16. Organized situations, from simple to complex, which give me a choice of where I want to start, stop, or branch out to something new.	16.					
17. Learning activities that have no planned goals, you set your own and do what you want.	17.					
18. Working alone and setting my own pace, choosing my own goals and objectives.	18.					
19. A course that allows me to plan my own learning steps to follow.	19.					
20. Student designed and directed instructional activities.	20.					
21. Classes which have as little organization as possible.	21.					
22. Instruction completely planned and set up by me.	22.					

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