An investigation into the cognitive styles of community college students and the effects of instructional treatment on their mathematics achievement.

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An Investigation into the Cognitive Styles of Community College Students and the Effects of Instructional Treatment on their Mathematics Achievement

A Dissertation Presented
By
Mary Ann Cullen

Submitted to the Graduate School of the University of Massachusetts in partial fulfillment of the requirements for the degree of DOCTOR OF EDUCATION
February 1980
Education
An Investigation into the Cognitive Styles of Community College Students and the Effects of Instructional Treatment on their Mathematics Achievement

A Dissertation Presented

By

Mary Ann Cullen

Approved as to style and content by:

Dr. Portia Elliott, Chairperson of Committee

Dr. Charlotte Rahaim, Member.

Dr. Doris Stockton, Member

Dr. Mario Fantini, Dean
Education
DEDICATION

To my parents, Garrett J. and Mary G. Cullen
who encouraged me to surmount difficulties
in making the dreams of yesterday, the reality
of today.
ACKNOWLEDGEMENTS

Sincere appreciation is due to numerous people who consistently supported and encouraged me throughout the doctoral program. Among these persons, a special debt of gratitude is due to:

---Dr. Portia Elliott, my conscientious chairperson, whose diligence, expertise and constructive criticism helped the study unfold.

---Dr. Charlotte Rahaim, the energetic optimist, whose concern for various levels of post secondary education prompted her to establish a unique professional development program for faculty members of the community and four-year colleges.

---Dr. Doris Stockton, the ever gracious mathematician, whose responsible professionalism and constant kindness will ever be an inspiration.

---Joan, Norinne and Alfheid, my faithful friends, who listened, criticized, cajoled and encouraged.

---My colleagues and the students at Mount Wachusett Community College for their enthusiastic cooperation and support throughout the study.

---My family and friends who were always there when needed and who never failed to understand.
ABSTRACT

An Investigation into the Cognitive Styles of Community College Students and the Effects of Instructional Treatment on their Mathematics Achievement

February 1980

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Directed by: Dr. Portia Elliott

Since a large percentage of community college students have different academic characteristics and cultural backgrounds from their university peers, it could be that they might learn best using a different mode of instruction from the lecture method. Before attempting to prescribe an educational alternative, it appears essential to determine first how these more mature students learn.

Numerous learning or cognitive styles have been researched. From the teaching experience of the author, two of these cognitive style categories which had particular relevance to community college students were field-dependence-independence and right and left cerebral hemisphere dominance. The literature suggested that students who were field-dependent and those who used right hemisphere processing techniques suffered most in our educational system since it favors those who employ the opposite style. Hence, the field-
dependent and the right hemisphere dominant are often academically weak, and they may constitute a large proportion of the students who matriculate at a community college.

If the cognitive style of each student were known, then an interaction between cognitive style and the mode of instruction could be chosen which would either compensate for, capitalize on, or challenge the students' particular learning style. The interaction chosen for this study was to capitalize on the facets of the field-dependents' and the right hemisphere dominants' learning preference. Extensive guidance and numerous supplementary materials favoring the field-dependents were provided in the Learning Center for the experimental group, and the mathematical topic chosen, Linear Inequalities, was taught using extensive graphing and visualization favoring the right hemisphere dominant. The time factor was the same for both groups, only the modes of instruction varied.

During the initial class, the students took a mathematical pretest and eventually two tests of cognitive style: the Group Embedded Figures Test (GEFT) for field perceptions, and Your Style of Learning and Thinking (YSLT) for hemispheric preference. In addition, 75 percent of the students participated in the videotaping for the Lateral Eye Movement (LEM) test, which was used in an attempt to validate outcomes on YSLT. The experimental group spent part of their assigned class time in the Learning Center, while the control sections had the traditional lecture presentation. When the
behavioral objectives had been completed, a mathematical achievement test was administered.

Using a t-test, it was found that these community college students were significantly more field-dependent and more left hemisphere dominant than those in the norming sample. The chi-square analysis showed that there were significantly more students who were field-dependent than field-independent; more students who processed information relying on their left hemisphere rather than their right hemisphere. Research appeared to indicate a relationship between the characteristics of those who are field-dependent and those who are right hemisphere dominant; between those who are field-independent and are left hemisphere dominant. However, the correlation analysis did not support this thesis.

The mathematical achievement of the experimental group significantly exceeded that of the control group. According to the t-tests, this same successful pattern was repeated for the experimental subgroups classified as field-dependent and as left hemisphere dominant when they were compared to their counterparts in the control sections.

Instead of using t-tests or F-tests, it has been suggested (Cronbach and Snow, 1977) that a more appropriate test for determining interactions would be regression analysis. The regression analysis yields a slightly different perspective. The
regression of the unit test on the GEFT score once again demonstrated that the more field-dependent the students, the better suited they are to the experimental milieu. The results of the regression analysis for hemispheric dominance were more tenuous due to the subjective nature of YSLT. From this data, it appears that the greater the dependence on the left hemisphere, the more comfortable the students would be in the lecture classroom. The stronger the preference for right hemispheric techniques, the greater would be their success in the experimental group.

The positive results of portions of this study highlight the possibilities for improving mathematics instruction using one or more of the cognitive styles of the student as a basis for prescribing the mode of instruction.
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CHAPTER I
INTRODUCTION

In 1972, while testifying before a Congressional Committee, Elliot Richardson (1972, p. 37), who was then Secretary of Health, Education and Welfare, said:

The approach that will work is the approach that carefully assesses the learning styles of children on a classroom by classroom basis and then adapts the teaching styles, curriculum, and instructional materials to take advantage of the learning styles of the children.

Fundamentally, Mr. Richardson is speaking about the purpose of this investigation: a cognitive style diagnosis and an instructional treatment. It should be noted, however, that he specifically refers to "children." Most research on learning styles and appropriate prescriptions have dealt with children, but only a few have concentrated on the student in the only American educational invention - the community college.

The seeds of the community college system were sown in 1851 when Henry P. Tappin published, University Education, in which he advocated transferring the first two years of college to the secondary schools. He and other educators believed that the first two years are occupied with non-university instruction and the students are still more adolescent than adult. The idea germinated for fifty years until the first public junior college was established in Joliet, Illinois in 1901.
California was the first state to pass legislation authorizing the establishment of local junior community colleges in 1907. Massachusetts, which, back in 1646, had ordered every township of one hundred families or more to establish a grammar school to prepare young people for the university, was one of the last states to establish a community college system. By an act of the legislature, the community college system was established in Massachusetts in 1958. The system now has fifteen community colleges scattered at strategic geographic locations throughout the Commonwealth and currently enrolls more than 28,000 students.

The original intent of educators, politicians, and citizens advocating public community colleges was not to establish more universities but to provide a broad and flexible curriculum which would meet the needs of the people in their own areas. The masses had neither the ability nor the desire to pursue advanced academic subtleties, but these same masses had an ever expanding faith in the power of education to open the doors of social and economic opportunity for them. Some community colleges fulfilled these aspirations while others sought to emulate their university neighbors and copied the four-year curriculum, and the instructors in these community colleges taught in the four-year model--by lecture.

The battle cries of the late 60's for relevance forced post-secondary institutions to take an honest look at their objectives and the manner of their implementation. To offset the admissions
selectivity that had developed in many community colleges, the Open Admissions policy was adopted almost nationwide (Monroe, 1972). In a November 6, 1973 policy memo, the Massachusetts Board of Regional Community Colleges (MBRCC) mandated that

...any person having a high school diploma or the equivalent...or any mature individual who does not have a diploma or the equivalent but whose experience and motivation make the successful completion of a given program likely, shall be admitted.

The ramifications of this community college policy are still being examined. Special programs have been and will be inaugurated for those students admitted to the community college without high school diplomas or without having had to take qualifying examinations. Such programs are essential if underprepared students, admitted under the MBRCC 1973 policy, are eventually to follow a college curriculum. The students may be admitted without the necessary prerequisites, but when they eventually graduate, they must be prepared for a chosen career or for transfer to a four-year institution. In many cases this takes longer than the normal two years, and it certainly requires unique approaches to instruction. In the 1970's, numerous innovative teaching techniques, skills centers, and pacing variations (Cross, 1976) were inaugurated, but despite these changes, the community college is still struggling to form its own identity and not to imitate the university.

Community college enrollments nationwide escalated from 168,000 in 1950 to 3,943,000 in 1977 (Statistical Abstracts, 1978). The
change was not only quantitative but qualitative as well since during that time most states had adopted the Open Admissions policy (MBRCC, 1973) which removed access barriers, thus admitting students who are not the typical university students in age, culture, background, and especially academic achievement (Cross, 1971; 1976; Roueche and Pitman, 1972).

Typical of the enrollment pattern across the nation are statistics from Illinois (1978) where in the fall of 1978, 68 percent of the community college students exceeded twenty-one years of age. Since community college curriculum is based on a two year cycle, it is also evident that the majority did not enroll directly from high school. In general, the community college student (Cross, 1976) ranked in the lowest third of his/her high school class, had serious deficiencies in reading as well as in mathematics and two-thirds of them were among those in the first generation in their families to attend a post-secondary institution. Until declining enrollments forced the universities to reconsider their admissions policies, the students with financial, cultural, and academic problems generally matriculated at the community college.

One community college whose students generally fit the characteristics listed above is located in central Massachusetts. This rural campus has an innovative Learning Center with successful programs in remedial English and reading but mathematics is still taught by the traditional lecture method. An effective alternative
mode for teaching mathematics is needed at this community college.

The faculty at many community colleges have realized that academic alternatives are necessary and have intensified their search for different modes of instruction. An academic revolution began in the community colleges, when, between 1970 and 1974, the number of campuses using programmed instruction rose from 44 percent to 74 percent; those using self-paced modules increased from 31 percent to 68 percent; facilities having a skills center or a learning center went from 36 percent to 76 percent (Cross, 1976).

Initially, the formula for improving instruction was based on applications of Skinner's (1968) stimulus-response techniques, notably programmed instruction and teaching machines. The effective use of both programmed instruction and self-paced modules depend heavily on Bloom's (1973) concept of mastery learning. A study by Gagne, et al. (1973) failed to find evidence of the effectiveness of the repetition, as found in some individualized modules, on learning and remembering. Educators opposed to the regimentation of the Skinnerian model, tend to gravitate toward using the discovery technique (Brunner, 1961; 1973). Educational alternatives abound but have yet to be extensively tried with the community college student.
Statement of the Problem

In our complex, technological society, an increasing level of mathematical competency is necessary for survival. At this same time, the mathematical competency of high school students taking the Scholastic Aptitude Test (SAT) is decreasing. In 1956-57, the mean was 496 and in 1976-77 it was only 471 (Braswell, 1978). Those who matriculate at community colleges are usually well below the mean in mathematics on the SAT and hence, they are unable to begin a regular college level course in mathematics. In 1974, 93 percent of the community colleges surveyed (Cross, 1976), made some provision for students who did not meet the traditional academic requirements. In many instances, remedial courses were inaugurated, but the mode of delivery was still the centuries old lecture method. The mathematics courses, at the community college where the study was conducted, are generally taught by the lecture method. Consequently, one of the purposes of this study is to provide sufficient data to inaugurate some different modes of instruction. This alternative is necessary since it has been shown (Coldway, 1974; Taveggia, 1977) that the lecture method is not necessarily the best for all students.

To use educational alternatives such as the facilities of a Learning Center, programmed instruction and self-paced modules would undoubtedly be helpful for many students. However, the
decision about which method to adopt could be made more wisely if the instructor knew some of the factors of the student's cognitive style. Using the mode of instruction most complementary to the student's learning style or providing appropriate exercises which would encourage the development of alternative learning styles may improve mathematical achievement.

Succinctly, if, in reality, the community college mathematics student has different learning styles from those of the typical college student, what are some of these styles? Can appropriate aptitude treatment improve the mathematics achievement levels of these students?

**Purpose of the Study**

This investigation was undertaken to see if any of the current educational innovations would raise the mathematics achievement levels of students in a rural community college. Initial studies do not indicate unqualified success in either programmed instruction or self-paced modules (Cronbach and Snow, 1977). Research in general concludes that the perfect method instruction for all students has yet to be found. This outcome might be the result of fitting the student to the program rather than selecting a program to meet the student's learning style. Since there is no method which is a panacea for all students, perhaps there are some methods which are more successful for students with a particular
cognitive style. A familiarity with the characteristics of the
cognitive style of the students might enable the instructor to
choose a more effective method of instruction for a particular
group.

A major problem is to determine the cognitive style of each
community college student. Witkin and his associates (1973; 1974;
1976) have done extensive research on a distinctive cognitive
style called field-dependence-independence but have not gathered
data for the community college students. Cross (1976) in her
book Accent on Learning, hypothesizes that the community college
enrolls an exceptionally large number of field-dependent students.
If this hypothesis is true, then it should be reflected in the
community college instructional techniques.

Another cognitive style characteristic which could have an
impact on community college students is brain lateralization
dominance. Hunter (1976) theorizes that we have "Right Brained
Kids in Left Brained Schools." If this theory is true for
community college students, steps should be taken to alleviate
the academic problems created by this facet of cognitive style.

This study hopes to determine the extent of field-dependence
and the lateral hemispheric dominance of a sample of community
college mathematics students. Cognizance of a student's learning
style would enable the instructor to offer more effective alter-
natives in an instructional treatment. The academic mode could
either match the student's style or when necessary, complement
the cognitive preference of the subjects and thus challenge them
to expand their manner of solving problems. A judicious choice
of educational paradigms should enable the students to improve
their level of mathematical achievement.

Research Questions

The primary purpose for undertaking this study is to attempt
to locate some method(s) of instruction that will improve the
mathematics achievement level of the students at this community
college. Cronbach and Snow (1977) feel that past research has
concentrated on the relationship between ability and achievement
but has neglected other factors, such as cognitive style, which
may significantly influence the learning process. Finding
this interaction of individual differences among learners
with instructional treatments is called Aptitude Treatment
Interaction (ATI). In this study, the teacher expects to use a
mode of instruction (treatment) that will complement the learning
styles (aptitudes) of the students and so the experiment is an
Aptitude Treatment Interaction. Instructional decisions on
educational alternatives should be based on a whole complex of
student characteristics if these characteristics actually influence
achievement. But first one has to determine:

1. What are the learning styles of these community
college mathematics students?

The first cognitive style which will be considered in this study is field-dependence-independence. A field-dependent student needs extensive guidance, whereas a field-independent student will make discoveries on his own (Witkin, 1977). It would appear that people in each of these two categories learn best using two different methods.

Originally, field-dependence was established on an individual basis using complex physical apparatus. However, during the last decade, Witkin and his associates (1971) have validated the Group Embedded Figures Test (GEFT) which can be administered in an ordinary classroom. The GEFT is available on a commercial basis and will be utilized in this study.

People whose right hemisphere dominates their learning style prefer a global approach to solving problems, while those whose left hemisphere dominates their thinking learn best by using a step-by-step sequential process (Wheatley et al., 1978). A judicious blend of both left and right hemispheric processing might be effective since it would enable the student to succeed with any problem whether visual or verbal.

In general, research on which hemisphere dominates a person's physical and mental functioning has taken place in the physician's office or the psychologist's laboratory, but only a negligible amount of study has involved the classroom and educational aspects
of information processing. A 1977 instrument, Your Style of Learning and Thinking, is now available for group use.

2. Is there a relationship between the cognitive styles of field perceptions and hemispheric dominance?

There appears to be a similarity between the characteristics of those who are field-dependent and those who process information using the right hemisphere, between people who are field-independent and those who use their left hemisphere for processing information. If this similarity is more than a conjecture, instructional methods could be adopted which would meet the needs of two cognitive styles at the same time. Since there is an insignificant store of research presently available on this relationship, any noteworthy correlation would link two important cognitive constructs.

3. Can mathematical achievement be improved with appropriate Aptitude Treatment Interaction (ATI) based on the knowledge of the cognitive styles of the learners?

Approximately half of the participants will have a mode of instruction which should complement their learning style. The remainder may be adversely affected by this same treatment. Mathematical achievement will be determined using a pretest and a post-test for the unit studied.

4. Which treatment had the greatest effect on the mathematics achievement of these community college students?
It is possible that the lecture method is still best for motivating the students to maximum achievement for one or both of the learning styles previously mentioned. It is also feasible that the interaction of learning styles with appropriate treatments may produce higher mathematical achievement. The answer to this question is of vital importance to educators who are constantly searching for effective instructional alternatives.

To succinctly summarize the problem, we might take Dr. Benjamin Alexander's (1979, p. 12) statement, "It is commendable that we teach remediation but reprehensible that we have to" and paraphrase it to read, "It is commendable that the community colleges have adopted innovative programs but reprehensible that they have fitted the student to the program rather than the program to the student."

**Definition of Terms**

**Aptitude Treatment Interaction**

-the attempt to locate the interactions of individual differences among learners with instructional treatments. An interaction is said to be present when a situation has one effect on one kind of person and a different effect on another.
Cognition
-the process by which knowledge is acquired.

Cognitive Style
-stable individual preferences in modes of perceptual organization and conceptual categorization of the external environment or, quite simply, the characteristic way of using one's mind.

Field Dependent
-a person who is dominated by the prevailing field, needs extensive guidance, and is more interested in people than in things.

Field Independent
-a person who is not influenced by the prevailing field, works independently, and is somewhat product oriented.

Integrated Hemispheric Dominance
-a method of combining the functioning of both the right and the left hemispheres of the brain to process information, common in one characterized by the ability to use an appropriate blend of both sides to solve problems.

Left Hemisphere Dominance
-a preference for using the left hemisphere of the brain to process information, common in one characterized by skill in reading, verbal expressions, computation, and approaching problems sequentially a step at a time.
Right Hemisphere Dominance

-a preference for using the right hemisphere of the brain to process information, common in one characterized by proficiency in spatial relations, drawing, music, and taking a global view of problems.

Implications of the Study

This study purports to validate the thesis that instructors should employ a spectrum of methods for teaching mathematics to community college students. If the experimental group is more successful than the control group, the treatment which produced the favorable outcome could be continued and expanded to include most mathematics courses at the college.

Since there is so little data available on the cognitive styles of community college students and the outcomes of aptitude treatment interactions, any valid studies should be valuable for other community college research. A single study does not provide enough evidence for an educational revolution, but does provide insight into what is happening in one small segment of the academic community and to what could happen elsewhere in similar circumstances.

Should the results of the experiment indicate that the field-dependent student achieves better than the field-independent student in a maximum guidance situation, this interaction knowledge will
enable the instructor to estimate the amount of guidance needed for students with these bipolar styles. All disciplines do not require field-independence, but to succeed in mathematics, under the way it has traditionally been taught, the student has had to be able to work independently. If this instructional treatment promotes improved (however slightly) achievement, it is worthy of consideration and additional study.

In theory, many of the characteristics of the poles in field dominance and hemispheric processing preferences seem to overlap. At this time, there has been extensive separate research on each of these cognitive styles but none available to date which studied this overlap and its effect on academic achievement. Should there be a correlation between field-dependence and right hemisphere dominance, or between field-independence and left hemisphere dominance, this relationship would be important in cognitive mapping, in furthering definition constructs for both areas, and in the educational sphere since these two characteristics could be dealt with simultaneously. In prescribing the appropriate level of guidance necessary for each student, the instructor could also make available materials suited to either the analytical and sequential modes in solving problems or curricula to aid the development of his/her spatial-visual capabilities. Since both right hemisphere dominants and field-dependents seem to have benefitted least from our present education system (Cross, 1976; Hunter, 1976; Samples, 1975), the
knowledge of this correlation could enable the educator to provide a more effective approach for choosing alternatives in modes of instruction.

**Delimitations of the Study**

In this study, no consideration will be given to the intelligence of the student or to his/her previous level of mathematical achievement, although in this latter case the student has had some success since he/she has reached a level beyond a semester of algebra. Supposedly, the class roster is a random assignment by the computer, but it would be false to assume that the classes are uniformly heterogeneous since other high level classes such as physics or circuit analysis may be scheduled at the same time as the experimental mathematics class and skim off too many of the better students and vice versa.

Only two of many well researched cognitive styles have been investigated in this paper, yet it is possible that some other style(s) may have a more pronounced influence on the mathematical achievement of some or all of the students. Since the cognitive style studied by McKenney and his colleagues (1974) at the Harvard Business School which employs a four dimensional model: perceptive systematic, perceptive intuitive, receptive systematic or receptive intuitive, has been valuable in aiding business management students in information processing, might it not be equally effective with
community college students? Or perhaps Guilford's convergent and divergent types of cognitive operations which have been incorporated into Kolb's (1976) Learning Style Inventory would better characterize the community college student. It would be impossible to study all cognitive styles, but two were chosen which have been established by years of research in the psychological laboratories and in a limited degree in the educational sphere.

There has been no allowance made for the fact that the experiment was conducted and taught by the same person. It is conceivable that the enthusiasm of the instructor, who was also the investigator, might affect the students and influence the outcome. Although there is some evidence (Witkin, 1977) to indicate that students like best those teachers who have the same cognitive style, the effect of interpersonal relations between a student with one cognitive style and the teacher with another has been ignored.

Cognitive styles are numerous, personal characteristics of teachers and students are myriad, and environmental factors are sometimes uncontrollable, so it is impossible to determine all of the variables that delimit the educational process.

Remaining Chapters

In Chapter II, the literature pertaining to mathematics instruction and community college students, to cognitive styles, particularly field-dependence-independence and cerebral hemisphere
dominance will be reviewed. In addition, possible aptitude treatments will be surveyed. Chapter III will give details of the pilot study, the design of the study, the participants, the methods of collecting data and the content of the module that was covered. The collected data will be analyzed in Chapter IV to determine the validity of the research hypotheses. The final chapter will summarize the results, draw appropriate conclusions, and make suggestions for future research.
CHAPTER II
THE LITERATURE

A review of literature relevant to the topic of study will focus on five areas: 1) literature concerned with mathematics instruction of community college students 2) cognitive style overview 3) cognitive style: field-dependence and field-independence 4) cognitive style: right and left hemispheric dominance as it relates to the learning process and 5) aptitude treatment interactions in mathematics education research.

Mathematics Instruction and Community College Students

Over the past twenty years (Braswell, 1978) the scores on the Scholastic Aptitude Test have been steadily declining. In 1956-57 the mathematical mean was 496, while in 1976-77 it had dropped to 471. This occurred in an era when there was great concentration on "modern math," as a means of improving achievement. If all other factors are equal, the four-year colleges and universities will skim off those above the mean leaving those below the mean to attend a community college. Roueche (1972) found that 75 percent of freshmen entering community colleges in California had to take mathematics courses similar to those taken by students in high school. Maxwell (1977) claims that 75 percent of the 17 year olds (one year younger than many college freshmen) and many young adults have not reached Piaget's (1971) stage of formal operations which is so necessary to understand
the abstract concepts of mathematics. In the fall of 1976, a group of engineering students at the University of Massachusetts was tested for their level of formal reasoning, and the results demonstrated that these students had reached a more mature level of cognitive development than those studied by Maxwell. Lochhead (1976), the Director of this Cognitive Development Project, found that fewer than 5 percent of these specialized students had not reached Piaget's level of formal operations.

Somewhere between this 5 percent and 75 percent of students who have not attained Piaget's formal operational stage, one would expect to find persons who matriculate at a community college. Most of them fit into the Maxwell category of being young adults. Among these same young adults are a few who may be majoring in electronic engineering technology and hence would undoubtedly possess the attributes of the subjects in the Lochhead study. The stages of cognitive development that the student has reached is another factor worth considering in planning instructional programs.

Ausubel (1969) asserts that mathematics instruction has unique problems in that its degree of sequentiality requires that prior tasks be thoroughly learned to ensure that the student will adequately comprehend what follows in the sequence. In this same text, the author highlights another factor which limits the success of students and that is their great difficulty in comprehending algebraic symbolism.
For subjects which use symbolism like mathematics, different methods of instruction must be devised as alternatives for persons who do not learn in the traditional pattern. Some new approaches have been tried and failed (Dubin and Taveggia, 1968), perhaps because they fitted the student to the program and not the program to the student. Roueche and Pitman (1972) feel that college students perform best when individualized instruction is developed to accommodate learning styles and individual student needs.

Akst (1978) lists about 60 research articles dealing with "Remedial Mathematics in the College." The instructional modes studied include: audio-tutorial methods, self-pacing, programmed modules, mastery learning, contract learning, self-instruction, television presentations and the use of mathematics learning centers. Over 90% of these studies have been undertaken since 1971. Although several of these research projects compare methods such as audio-tutorial programs, programmed instruction, or the contract method with the traditional lecture approach, apparently few of them considered the student's learning style before determining the program to be used. At two of the community colleges in Massachusetts, an attempt has been made to determine the cognitive style of the students, but at this time, these learning styles have not been used as a basis for assigning students to a particular mode of instruction.
Of the eighteen learning centers or math labs located on campuses outside the Commonwealth and visited by the investigator, several were commendable for their educational innovations and one determined cognitive style and prescribed treatment accordingly. At Miami Dade Junior College (Palow, 1978), after a mathematical pretest and the Canfield-Lafferty Learning Styles Inventory are given, the computer scores the diagnostic instruments and then writes a letter to the student indicating his/her professed learning style and a suggested mode of instruction at the appropriate mathematics level. Instruction is not by computer, but after the units are completed, the test results are graded by the computer and returned to the student with suggestions on the incorrect problems. It appears to be a successful application of computer managed instruction (CMI).

At the other end of the scale, El Centro, uses the computer assisted instruction (CAI) but only to provide drills for remedial students. All mathematics courses are on a completely individualized basis with the usual assortment of programmed materials, tapes and talking pages to augment personal assistance. This individualization has enabled El Centro to offer courses with small enrollments without creating staffing problems. However, since there is only one mode of instruction--individualized--there is no attempt to determine the cognitive style of the student.
Cognitive Style

Cognitive Style Overview. The term "cognitive style" implies an habitual pattern or preferred strategy of information processing (Cronbach and Snow, 1977). A knowledge of cognitive style can contribute to the understanding of individual differences in the processing of information and assist in the selection of more effective modes of instruction, e.g. a personalized system of instruction (Keller, 1974) or a combination of group and individualized instruction with extensive use of media such as the Audio-Tutorial method of Postlewait (1972).

Cognitive styles appear to have several sources: in family relationships (Witkin, 1971), in national culture (Ludwig, 1978; Witkin and Berry, 1975) and in educational practice (Cross, 1976). In interpreting some styles, e.g. field-dependence-independence (Witkin et al., 1971) and hemispheric dominance (McGlone, 1978), sexual differences must be taken into account since there is some variation in the norming means for each sex. The level of a particular cognitive style tends to remain relatively constant (Witkin et al., 1962) throughout a person's life with the person remaining at the same position on the scale with respect to the general population while increasing or decreasing according to maturity. Coop and Sigel (1972), reported on two studies where students taught in a manner consonant with their cognitive style
improved their level of achievement. The subjects for this successful research were elementary school children, but when a similar project was attempted with college level participants, the outcome failed to support the expectations. Hence, these authors question whether the influence of cognitive style is as pervasive a factor in the academic improvement of college students as it is in young children.

Table 1 on p. 25 lists several cognitive styles still under investigation. On close scrutiny, there appears to be some overlap among these styles of learning. An attempt has been made to place those with similar characteristics in the same column. It should be noted, however, that researchers use the same term to convey different concepts, e.g. Witkin uses the term "analytic" to denote a person who is field-independent in his perceptual orientation, while Kagan, Moss and Sigel (1963) use "analytic" as a label for those people who tend to categorize environmental stimuli on the basis of objective parts of that environment rather than on the whole of the environment.

Of the cognitive style classifications listed in Table 1, this researcher will be primarily concerned with field-dependence-independence and with hemispheric specialization.

Cognitive Style: Field-Dependence-Independence. For more than a quarter of a century, Witkin has been researching the cognitive
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<tr>
<th>Bipolar Cognitive Style Classifications</th>
<th>Researcher</th>
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<tr>
<td><strong>Left Hemisphere Dominance</strong></td>
<td><strong>Right Hemisphere Dominance</strong></td>
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<td><strong>Systematic Receptive</strong></td>
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<td><strong>Flexible Control</strong></td>
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<td><strong>Complexity</strong></td>
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<td><strong>Active</strong></td>
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<td><strong>Guided Discovery</strong></td>
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<td><strong>Broad Inclusiveness</strong></td>
<td><strong>Narrow exclusiveness</strong></td>
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<tr>
<td><strong>Concept formation of functional relations</strong></td>
<td><strong>Analysis of descriptive attributes</strong></td>
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N.B. This is not an exhaustive list, but rather the prototypical cognitive style classifications suggested in the literature and reflects this author's attempt to categorize them.
style known as field-dependence-independence. Witkin's (1962; 1974; 1977) first experiments involved placing the subject in a darkened room and asking that a tilted rod and a separate tilted frame be straightened. If the subject was dominated by the field, he/she would align the rod with the frame, whereas if the subject was not dominated by the prevailing field, he/she would bring the rod close to an upright position. Persons who ignored the tilt of the room and the slant of the frame were described as field-independent, while those who relied on their surroundings were termed field-dependent. Later, a pencil and paper, Group Embedded Figures Test, (GEFT), was devised by Witkin and his associates to replace the physical apparatus for determining field-dependence. A high consistency has been found (Witkin et al., 1971) in a person's performance on the Rod and Frame Test, the Embedded Figures Test and the Group Embedded Figures Test.

Witkin (1962) found that field-dependent persons prefer to be directed by others, spend time looking at the faces of those with whom they interact and lack a well-developed sense of their own identity while the field-independent person is inner directed. According to researchers (Cross, 1976; Ludwig, 1978; Witkin, and Moore, 1974), field-dependents are more proficient in social situations, like to be physically close to others and prefer careers involving people and human relations in contrast to field-independent
persons who tend to be more individualistic, have significant personal autonomy and prefer careers in the sciences. In addition, experts (Cross, 1976; Witkin, 1974) assert that the field-dependent person favors tasks with a global view and needs extensive guidance whereas the field-independent person favors learning that requires separation of elements from the background and will make discoveries without assistance.

In themselves, cognitive styles like field-dependence or field-independence are value neutral because it is not inherently good or bad to be located toward one or the other end of its poles (Witkin, 1977). In addition, cognitive styles take on value connotations (Kogan, 1976) only when the successful completion of a task requires a specific learning or personality skill.

Witkin (1977) asserts that field-dependent students are not likely to be interested in, or do well in mathematics, and he also theorizes that this may be the result of the way that mathematics is currently taught and the people who teach it. Mathematics teachers are likely to be field-independent and their teaching methods would be related to their own cognitive style so that field-dependent students may be mismatched to field-independent teachers. It is possible, then, that a change in the method of teaching mathematics may well improve the mathematical achievement of the field-dependent student.
In Accent on Learning, Cross (1976) hypothesizes that field-dependent people are overrepresented among community college students, since their traditional prior education has inadvertently not been focused on the field-dependent's cognitive style but has been geared to the style of the achievement motivated, task oriented, field-independent student. Researchers (Cross, 1976; Witkin, 1977) are not necessarily encouraging the changing of a field-dependent to a field-independent person but rather suggest that students be given the option to either use their cognitive strength or to expand their preferred learning modes so that, when necessary, they are able to adopt other learning strategies that are effective in particular situations.

Cognitive Style: Hemispheric Specialization. Since 1861, when the French physician, Paul Broca, first discovered the lateralization functions in the cerebral cortex (Lassen, Ingvar and Skinhoj, 1978), extensive research has been done on the physical implications of cerebral specialization. This information has been gathered through necessary surgery, through the split-brained research of Gazzaniga, Sperry and Myers (1967), during electroencephlographic (EEG) experiments (Ornstein and Galin, 1974), and in one instance during electroconvulsive shock treatment for severe depression (Cohen, Berent and Solverman, 1973). A newer, more precise method of gathering information about hemisphericity has been developed.
(Lassen, Ingvar and Skinhoj, 1978) which measures the flow of blood in a particular area of the cortex. This flow, traced by the injection of the radio-active isotope xenon-133, has been found to be proportional to the activity of nerve cells in this area, i.e. strong activity areas show up on the scope in bright red, while passive, inactive areas are blue.

The preceding instruments requiring expensive equipment and highly trained professionals are effective for testing on an individual basis. For administration to large numbers, a more convenient instrument is needed. There is continuing research on lateral eye movement tests (Bakan, 1971; Kocel, Galin, Ornstein and Merrin, 1972; Weiten and Etaugh, 1974) which videotapes willing participants who are responding to a series of questions which would ordinarily activate either the left hemisphere, the right hemisphere, or both hemispheres. The hemispheric activity is contralateral to the direction of the eye movement.

These individual physical tests, as well as the recently developed pencil and paper inventory (Torrance et al., 1977) which may be administered to groups of subjects, have facilitated not only the determination of which hemisphere dominates the physical activity of a person but also gives cues to his/her learning style. Recent years have witnessed an increased interest in studies on the applications of hemispheric specialization as guides to understanding the learning style of students (Torrance et al., 1977; Wheatley et al., 1978).
Research (Sperry, 1975; Wheatley et al., 1978) on a person's learning style indicates that those whose left hemisphere dominates their reasoning processes treat stimuli serially and are better at reading, speaking, analytic reasoning and algorithmic processes, while those whose right hemisphere influences their learning style process stimuli many at a time as a gestalt and are better at spatial tasks, recognizing faces and music. Torrance (1977) adds that the right hemisphere responds to visual instructions, is subjective in processing information, is creative, uses images to remember, and deals simultaneously with several problems, but uses intuition to solve them. On the other hand, the person whose left hemisphere is dominant will respond to verbal instructions, will be systematic and controlled in experimenting, will be objective in processing information, will deal with problems one at a time, sequentially, using logic to solve these problems. Succinctly, the left hemisphere is the language processing, sequential, if-then brain, while the right hemisphere is the global view, visual-spatial brain.

The influences of hemispheric lateralization appear even in infancy, where it was found (Turkowitz, Gordon, and Birch, 1965) that 88 percent of all newborns studied turned their heads so as to have their left ear and eye up to receive stimuli which are processed, at this preverbal stage, through the right hemisphere.
Ornstein and Galin (1974) support the theory of slow development of lateralization during childhood while Gazzaniga (1967) feels that in young children, hemispheric development is about equal with respect to language and speech. One study of the influence of sexual difference in hemispheric specialization on learning indicates that language appears to be organized quite differently in the brains of men and women (McGlone, 1978). Women have a much wider area controlling speech. In fact, it appears that in women, speech is a facet of both hemispheres.

Wheatley et al. (1978) have noted a corollary between the onset of hemispheric specialization at about age 7 or 8 and Piaget's (1971) progression from pre-operational to concrete operational stage of cognitive development. This consistent relationship continues a few years later when the young adult moves from Piaget's concrete operational stage to the more adult formal operational stage at approximately the same time that a person moves from a learning style where the right hemisphere dominates to a more adult stage when a left hemispheric processing procedure is involved. Maxwell (1977) found that 75 percent of the high school seniors and young adults in her sample had not reached this stage while Lochhead (1977) found that only 5 percent of the engineering students tested had not reached Piaget's stage of formal operations. From these observations it would appear that learning alternatives should
reflect the cognitive stage of the students.

There is some evidence that students can be assisted in reaching a higher level of cognitive development. Gazzaniga (1967), Sperry, and Myers experimented on animals to prove their theory that since each hemisphere is capable of learning functions normally performed by the other hemisphere, then if the corpus callosum joining the hemispheres is severed, one really has two functioning brains. Hence, each hemisphere, given adequate practice should be able to perform any cognitive function so that a student who lacks proficiency (Sperry, 1975) in using either hemisphere could be given appropriate exercises to develop the desired skill. If spatial concepts are needed to solve a problem and the person normally processes information through the left hemisphere which favors verbalization, this learner, given sufficient exposure to right hemisphere techniques, should be capable of using a visual approach.

These findings are important to educators. Investigators (Hunter, 1976; Samples, 1975; Sperry, 1975) feel that the schools have emphasized training the left hemisphere and have ignored the factors necessary for the development of the right hemisphere. Teachers may occasionally find it useful to match the mode of presentation with the student's preferred mode of learning, but since adult situations often require complex thought processes using both hemispheres, the student should be encouraged in the integrated use
of his/her right and his/her left hemispheres (Wheatley et al., 1978). On the other hand, using a lateral eye movement test, Weiten and Etaugh (1974) found that individuals who move their eyes consistently in one direction in response to reflective questions score significantly higher on the Scholastic Aptitude Test than those who have crossed dominance.

If one compares the two cognitive styles of field-dependence and hemispheric dominance, some important similarities become evident. Persons who are field-independent (Witkin, 1977; Wheatley et al., 1978) and those dominated by left hemispheric processing techniques (Bakan, 1971; Sperry, 1975; Torrance et al., 1978) are classified as analytic. These same researchers claim that students with these characteristics deal sequentially with one problem at a time. Torrance (1978) feels that left dominant persons are systematic and controlled in learning, which implies that they should be more adept in working independently and making discoveries on their own which Wheatley (1978) cites as a facet of the field-independent personality.

Both the right hemisphere dominant persons (Sagan, 1977; Sperry, 1975; Torrance et al., 1978) and the field-dependent persons (Witkin, 1974; 1977) use a holistic or global approach to problem solving and are good at recognizing and remembering faces. The field-dependent individuals are interested in people (Witkin, 1977) and adept in
social situations, while those who generally use the right hemisphere for processing information respond to emotional appeals (Torrance, 1978) and readily interpret body language.

There still remains much work in educational research to confirm the theory that these two styles represent the same construct.

**Aptitude Treatment Interaction**

Cronbach and Snow (1977) in *Aptitudes and Instructional Methods* assert that it is imperative that instructional decisions be based on a whole complex of student characteristics and not just on one facet such as general intelligence. Since each student is unique, the search for superior methods should be paralleled by a search for ways to match the instruction to each kind of learner. This attempt to locate the interactions of individual differences among learners with instructional treatment is called Aptitude Treatment Interaction (ATI).

There was no consideration of interactions in a comparative analysis of college teaching methods made by Dubin and Taveggia (1969). They used over ninety studies to compare the results from using the lecture method and some alternative form of instruction and found, for example, that of 72 independent and non-independent comparisons, 47.2 percent favored supervised independent study and 52.8 percent favored lecture. On the other hand, Dubin and Taveggia also found that of 16 comparisons, 50.0 percent favored discussion,
31.2 percent favored the lecture method and 18.8 percent showed no difference. Had interactions been used, perhaps the results would have been more consistent.

An extensive interactive study was conducted at Oakland Community College in Michigan by the American College Testing Program (ACT). This study (ACT, 1977, p. 2) reports that a former president of Oakland, Dr. Joseph Hill, and his associates had developed a cognitive map which included "32 dimensions in three categories: (1) Symbols and Their Meanings (2) Cultural Determinants and (3) Modalities of Inference." Hill (1957), himself, had originally included a fourth factor, namely Memory Set, but this facet has proved very difficult to measure without sophisticated instruments and is frequently omitted in Hill Models. The researchers then attempted to determine if the use of the cognitive style map and a variety of methodologies suited to the student's map would improve instruction.

The mixed results were attributed in large measure to the lack of correlation between independent measures of the same cognitive style dimensions. One of the major conclusions of the two year study was that increased effort should be expended on the development of effective instruments for assessing cognitive style.

Without deliberately considering cognitive style, educators continually use intuition to devise and apply new instructional
treatments but only limited progress has been made towards a scientific, integrated understanding of individual differences in ability to learn with the concommitant formulation of principles by which the adaption of instruction can be made systematic and productive. In their text, Cronbach and Snow (1977) analyze numerous interactive studies where, in some cases the interactions were misrepresented, or, in others, the researcher was not cognizant of the interaction. Cronbach and Snow also supply numerous statistical and interpretative guidelines for future aptitude treatment interaction (ATI) studies. Young and Becker (1979, p. 35) feel that:

Certainly, much remains to be discovered in the field of ATI research. In these days of CAI, ever-increasing class size, and accountability, the problem of perfecting programmable treatments and of maximizing achievement could appear to be ever more relevant.

The "problem of perfecting programmable treatments and maximizing achievement" is essential for all levels of education but is particularly appropriate for community college students who often need remediation in addition to acquiring career skills in the short space of two years.
Chapter III
METHODOLOGY

Introduction

Chapter I summarized the growth and development of the community college and the unique characteristics of the community college student, with special attention concentrated on the mathematical difficulties of these same students. Chapter II focused on the literature related to research on some of the possible causes and proposed solutions for these learning problems, especially the cognitive styles of field perception and hemispheric dominance and the application of these theories to community college mathematics students. This chapter will discuss an exploratory study conducted by the investigator at a community college in Massachusetts during February, 1979. More specifically, the pilot study (conducted in November 1979), and the study including: the participants, design of the study, the instruments used, and the procedures for data collecting and analysis are described. An overview of the mathematics unit taught, during which time the data was collected, is also detailed in this chapter.

The major thrust of this work is to establish an alternative to the lecture method for teaching mathematics to community college students that will be cognizant of the difficulties inherent in the sequentiality (Ausubel, 1979) of mathematics and will reflect knowledge of students' individual cognitive styles. Therefore, this
investigation attempts to determine the relationship between the cognitive style variables: field-dependence-independence, left-right hemisphere dominance, and instructional treatment that differs along the dimension of level of guidance.

Pilot Study

Participants. In November, 1978, a pilot study was inaugurated with a sample of 61 precalculus students to determine two aspects of their cognitive styles and, based on this information, to prescribe and implement an appropriate treatment. The expectation was that this aptitude treatment interaction would improve the mathematical achievement of the participants.

It should be noted that precalculus students are usually among the best mathematics students at a community college. Some few may be admitted directly to this level when they matriculate, but most students follow a sequence of two or three lower level mathematics courses before attaining precalculus.

Unit Content. The mathematical topic used for the pilot study was "Relations, Functions and Transformations," a required unit in any standard precalculus course. This topic was chosen because the students rarely had more than a slight introduction to these concepts and almost none had used the approach of Keedy and Bittinger in Fundamental Algebra and Trigonometry, Chapter Three.
In addition, this chapter required computational and verbal skills that involve left hemispheric processing and at the same time needed visualization for graphing functions, visualization being a characteristic of the right hemisphere.

Results of the Pilot Study. The male students in this project were significantly ($p = 0.02$) more field-dependent than those in the norming sample. When the results of the test for hemispheric dominance were calculated, it was found that the subjects in the pilot study were more apt to use their left hemisphere than their right in solving problems. The correlation between field preference and lateral hemispheric specialization was contrary to the theoretical expectations. In all cases, the mathematics achievement was better for the students in the experimental groups, although only inter-group field-dependent scores were at a significant level ($p = 0.5$).

The Study

Participants. Eighty elementary algebra students constituted the sample used for the study in February, 1979. For two weeks, this investigator taught four sections, 37 (24 male, 13 female) in the two experimental classes and 43 (26 male, 17 female) in the control groups. Computer placement decreed student class assignments, while hours that were convenient for the Learning Center staff and
facilities resolved the problem of which group would be experimental and which would be control.

By February, most students have already survived at least one semester of algebra and are at the beginning of their second semester of mathematics. Many enroll because mathematics is required in their career or transfer program. Only a few have ever encountered the unit material previously, and these students have either barely passed it, have forgotten it, or last encountered it many years ago.

Design of the Study. Since the experimental and the control groups had been randomly assigned by the computer, it would be reasonable to assume that the cognitive style characteristics would be evenly distributed among the students. For the purpose of this study:

1. The traditional lecture method was used with the control group.

2. For the experimental group, there was a combination of lecture method for the introduction of concepts, and Learning Center individualization for mastery of these concepts within the same time constraints as the control group. Since the unit involved some visualization, an increased use of visual aids occurred with the experimental group. The former procedure favored the field-dependent, while the latter should elicit a favorable intellectual
response from the right hemisphere dominant.

3. It was expected that both the experimental and the control groups would have within them four observable subgroups: field-dependents, field-independents, right hemisphere dominants and left hemisphere dominants.

4. In the Learning Center, supplementary materials such as programmed units and worktexts with corresponding tapes were available for the experimental students to use during Learning Center sessions or at any other time that these students might choose. Some of the supplementary materials were prepared by the investigator while others were commercial products.

5. During the initial class, a pretest of mathematical knowledge (Appendix A) of the content of the unit was administered. Also, instruments were employed to determine the cognitive styles of field-dependence-independence (commercially available) and right and left hemisphere dominance (Appendix D) in both groups.

6. When the behavioral objectives of the unit (Appendix B) were covered, a summative test for mathematical achievement (Appendix C) was given.
The design of the study was almost identical for both the pilot and the main study. Elementary algebra students were used as the sample in the main study since they are more typical of community college students than the more mathematically sophisticated precalculus pilot subjects.

**Instruments.** The study was designed to provide structure in the attempt to answer the previously stated research questions and their corollary hypotheses. Understanding how the student learns can provide an effective basis for prescribing educational modes. Hence, the first question is:

**Research Question One:** What are the learning styles of these community college mathematics students.

A. **Field Perceptions**

1a. \( H_0 \): There is no difference in the mean score of field-dependence-independence in students in a community college mathematics course and the mean in the norming sample.

1b. \( H_0 \): There is no difference in the number of field-dependent and field-independent students in this set of community college students.

Cognitive style has many dimensions but only two of these were used in this study: field-dependence and hemispheric dominance. The Oltman, Raskin and Witkin Group Embedded Figures Test was
administered on the first day to evaluate the level of field-dependence-independence. The Embedded Figures Test frequently used in educational studies, has to be administered on an individual basis but has a reliability coefficient of 0.82 (Witkin et al., 1971) with the Group Embedded Figures Test which is more convenient for use with large groups. In this latter instrument, the student is asked to locate a simple figure in a complex diagram. Parts II and III that were used for data purposes were timed for five minutes for each section. Scores may range from zero to eighteen and the higher the score, the more field-independent the student is. The norms for the Group Embedded Figures Test were determined using college students.

To determine validity, the responses to items on the GEFT were compared to the parent instruments (Witkin et al., 1971): the individually administered Embedded Figures Test (male: \( r = -0.82 \); female: \( r = 0.34 \)) and the physical apparatus Rod and Frame Test (male: \( r = 0.39 \); female: \( r = -0.34 \)). These r's were negative because the tests were scored in reverse fashion.

B. Hemispheric Dominance

1c. \( H_0 \): There is no difference in the mean of community college students who use right or left hemispheric processing techniques and those same means in the norming sample.

1d. \( H_0 \): There is no significant difference in the number of students dominated by right hemisphere and by left hemisphere processing techniques.
It was more difficult to find a satisfactory instrument for determining hemispheric dominance. The only pencil and paper instrument appears to be *Your Style of Learning and Thinking* by Torrance, Reynolds, Ball and Riegel. Form A and Form B of this instrument are similar in content, but Form B was chosen since its vocabulary is more appropriate for community college students.

Using alternate forms, the authors (Torrance et al., 1978) found that the reliability coefficients for their undergraduate population were:

- Right Hemisphere Specialization: 0.84
- Left Hemisphere Specialization: 0.74
- Integrative Style: 0.85

Almost identical reliability coefficients were obtained using test-retest studies after an intervention period of six weeks.

The validity of *Your Style of Learning and Thinking* was determined partially by research on the specialized functions of the cerebral hemispheres and also by ten studies comparing outcomes on related instruments. Torrance was either the author or the co-author of six of these instruments and the validity coefficients were generally significant on eight of the ten preference type questionnaires.

The Torrance instrument is a self-testing inventory which allows the student to select which of three specific styles of learning and/or thinking best describes his/her own typical
behavior. Among the three choices, one represents a specialized function of the left cerebral hemisphere, a second represents a parallel specialized function of the right cerebral hemisphere, and the third represents an integrated functioning of both cerebral hemispheres.

A preference type of instrument, like Your Style of Learning and Thinking has a subjectivity problem. A sample of one of the questions may illustrate the point. The student is asked to:

Select the one that describes more accurately your strength or preference.

35. a) more creative than intellectual  
    b) more intellectual than creative  
    c) equally creative and intellectual

Many community college students would have difficulty in identifying whether their preference was creative or intellectual. In addition, to play it safe, many would probably choose category c and classify themselves as equally creative and intellectual.

A subjective instrument like Your Style of Learning and Thinking has two problems, namely:

1. Is the student really aware of his/her own typical mode of acting.

2. Is he/she reporting accurately or just checking what appears to be the best method of acting.
This dilemma has to be considered when evaluating data from this instrument and has already been reported as one of the limitations of this study.

As a means of checking the construct validity of the Torrance instrument, a lateral eye movement test was given to students who volunteered to subject themselves to this videotaping procedure, and this data is presented in Appendix E.

Since the treatment was focused on the needs of the right hemisphere dominant as contrasted to the left hemisphere dominants, it might have mixed results on the students in the integrated category. In addition, since the experimental and the control groups were drawn from a total population of 80 students, some very small cells could be created using the theoretically neutral integrated classification. Hence, this category was omitted from the study, and hemispheric preference was determined by the greater right or left percentile rank. This latter procedure was necessary since the Torrance test has different means for right and for left hemispheres.
Research Question Two: Is there a relationship between the cognitive styles of field perceptions and hemispheric dominance?

2. \( H_0 \): There is no correlation between field perceptions and lateral hemispheric dominance in the mathematics students in this community college.

Data from the instruments already described under Research Question One will be used in the attempt to answer this question.

Research Question Three: Can mathematical achievement be improved with appropriate Aptitude Treatment Interaction (ATI) based on

A. Field Perceptions

3a. \( H_0 \): (Intergroup) There is no difference in mathematics achievement as evidenced by increase scores between field-dependent (field-independent) students in the experimental group and field-dependent (field-independent) students in the control group.

3b. \( H_0 \): (Intragroup) There is no difference in mathematics achievement as evidenced by increase scores between field-dependents and field-independents in the experimental (control) group.

B. Hemispheric Dominance

3c. \( H_0 \): (Intergroup) There is no difference in mathematics achievement as evidenced by increase scores between right (left) hemisphere dominants in the experimental group and right (left) hemisphere dominants in the control group.
3d. \( H_0 \): (Intragroup) There is no difference in mathematics achievement as evidenced by increase scores between right and left hemisphere dominants in the experimental (control) group.

C. Field Perceptions and Hemispheric Dominance

3e. \( H_0 \): There is no difference between field perceptions, hemispheric dominance and mathematical achievement measured by increase scores in this set of community college students.

All of the hypotheses for **Research Question Three** involve measuring mathematical achievement. To assess achievement, it is necessary to know the student's previous mathematical level; therefore, a pretest (Appendix A) was given on the first day of class. The pretest in linear inequalities contained 10 questions, all of which were of equal point value. At the end of the main experiment, a unit test containing 14 questions was administered. The problems varied in difficulty and so the first 10 had a 5 point value, the next 3 were worth 10 points each and the last was a 20 point question involving several operations. Students turned in the pretest when they felt they had completed all they currently knew on the topic and all of the classes were finished within ten minutes. The unit test absorbed the better part of a full class period for most students. All mathematical tests were based solely on the content in the given unit and were reviewed and approved by two other department members for appropriateness of form and thoroughness of content and to establish content validity for these tests.
Research Question Four: Which treatment had the greatest
effect on the mathematics achievement of these community
college students?

4a. $H_0$: There is no difference in mathematics
achievement in the subgroups favored
by the treatment (field-dependence in
the experimental group, field-indepen-
dence in the control group) and the
subgroups not favored by the treatment
(field-independence in the experimental
and field-dependence in the control
group).

4b. $H_0$: There is no difference in mathematics
achievement in the subgroups favored
by the treatment (right hemisphere
dominants in the experimental and left
hemisphere dominants in the control
group) and the subgroups not favored
by the treatment (left hemisphere
dominants in the experimental group and
right hemisphere dominants in the control
group).

Mathematical achievement and cognitive styles are the funda-
mental factors in this research section. The assumption underlying
these hypotheses is based on research (Witkin and Moore, 1974;
Cross, 1976) which implies that students with one specific learning
style achieve best in situations which may provide an adverse
atmosphere for the student with the opposite cognitive style. Of
vital concern to this study is the determination of which sub-
group had the greatest achievement. All of the instruments needed
to obtain the required data have been described in the preceding
chapters of this chapter.
Unit Content. "Linear Inequalities" was the topic used for the study in the early weeks of February. For this period, the investigator replaced two other instructors. This unit, required by the elementary algebra curriculum, was selected because it could be taught without disturbing the regular instructor's sequence or procedures and is found in Chapter VII of J.P. Wood Elementary Algebra, the text being used by the class. Moreover, this material was best suited for the cognitive differences under consideration since it was both visual and computational. The content of the chapter is outlined below.

First Degree Inequalities

I. Order and the Number Line
   A. Symbols (>, <)
   B. Relationships Between Real Numbers

II. First-Degree Inequalities in One Variable
   A. Procedures Used in Solving Linear Equations
   B. Properties and Procedures Used in Solving Linear Inequalities

III. Solution Sets of First-Degree Inequalities in One Variable
   A. Algebraic Solution
   B. Graphic Solution

IV. Inequalities Involving Absolute Values
   A. Intersection of the Two Sets
   B. Union of the Two Sets
V. First-Degree Inequalities in Two Variables

A. One Inequality

B. Systems of Inequalities

Data Collection and Analysis. All data for this study was collected within the regularly scheduled class periods with the exception of the lateral eye movement test. All participating students were asked to sign a form (Appendix G) either consenting or refusing to allow their personal data to be used for research purposes. At no time in the analysis of the data will the student be identified by name.

The study utilized information furnished by the following sources:

<table>
<thead>
<tr>
<th>Test</th>
<th>Date Administered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest for prior knowledge of the content of the module.</td>
<td>February 5, 1979</td>
</tr>
<tr>
<td>Unit test for the knowledge of the content of the module at the end of the experimental period.</td>
<td>February 16, 1979</td>
</tr>
<tr>
<td>Group Embedded Figures Test by Witkin et al. for ascertaining the level of field-dependence-independence.</td>
<td>February 5, 1979</td>
</tr>
<tr>
<td>Your Style of Learning and Thinking by Torrance et al. for determining hemispheric dominance.</td>
<td>February 7, 1979</td>
</tr>
</tbody>
</table>

The data generated by each of the preceding instruments was scored by the researcher and the mathematical achievement grades
were checked by other departmental instructors. The **Group Embedded Figures Test** and **Your Style of Learning and Thinking** were analyzed in raw score form. The mathematics achievement tests were converted to percents as these were used to calculate the students' grades for the semester. In addition, since **Your Style of Learning and Thinking** scores had a different mean for each hemisphere, this variation would have created a problem in analysis. Hence the Torrance test raw scores were transformed to percentiles and the percentiles were employed to determine which hemisphere was most commonly utilized. T-tests were used to compare field preference and hemispheric dominance with established norms while the significance of the number of students in each field or hemispheric category was analyzed used the chi-square formula. Intergroup and intragroup mathematics achievement was examined with a t-test and, when cognitive styles were combined, with an analysis of variance F-tests. In all cases, p = 0.05 maintained as the level of significance.

A Pearson product moment coefficient was used to calculate the relationship between field-dependence and hemispheric dominance. For the final hypothesis comparing the results of the groups favored by the treatment and those for whom the treatment might be detrimental, a linear regression analysis coupled with the Johnson Neyman (Pedhazur and Kerlinger, 1973) formula for regions of significance was utilized.
The descriptive statistics were calculated using the computer language APL and the statistical package Adapt. The actual computation was executed at the Computer Center at the University of Massachusetts in Amherst.

Summary

Students were assigned to either the experimental or the control groups before the data on their respective cognitive styles or previous mathematical knowledge of the unit had been ascertained. After the preliminary testing, the instructional treatment was inaugurated and when completed, a unit test was given. The resultant data was computerized to yield the descriptive parameters which will be analyzed in the next chapter.
CHAPTER IV

RESULTS OF THE STUDY

Introduction

In order to ascertain whether or not instructors of mathematics at the community college should consider the cognitive styles of their students, it is necessary for the researcher to choose to study characteristics which have impact on academic achievement and have the possibility of prescribing a treatment which is within the realm of the staff and facilities of the college. Two such influences are the cognitive styles of field-dependence-independence and right and left hemisphere dominance. If these cognitive styles are present, then it should be possible to improve the mathematical achievement of the student either by using treatments that suit his/her cognitive style or by challenging the individual to expand his/her instructional options by learning to apply appropriate alternative styles.

In this study, the former approach was selected and, since the field-dependent student has been the underachiever (Cross, 1976) in the traditional class, the treatment of using maximum guidance was chosen to match the needs of the field-dependent student. While not used exclusively during class, there was extensive reliance on graphs and diagrams which would be the preferred mode of those dominated by right hemispheric techniques. Should the styles of field-dependence
be related to hemispheric dominance, the treatment could assist students having two different types of learning problems. In this instance and in all classroom situations, one has to be cognizant of the fact that real effects vary from one setting to another because of unanticipated interactions (Cronbach and Snow, 1977).

There were five sets of measures obtained for each subject: field-dependence-independence from the Group Embedded Figures Test, hemispheric dominance from Your Style of Learning and Thinking, a second measure of hemispheric dominance from the Lateral Eye Movement test (used for validity check), previous mathematical knowledge from the pretest and the mathematical level at the end of the experimental period from the unit test.

These measures were obtained to ascertain answers to the following research questions.

1. What are the learning styles of these community college mathematics students?
2. Is there a relationship between the cognitive styles of field perceptions and hemispheric dominance?
3. Can mathematical achievement be improved with appropriate Aptitude Treatment Interaction (ATI) based on the knowledge of the cognitive style of the learner?
4. Which treatment had the greatest effect on the mathematics achievement of these community college mathematics students?
An overview of the data gathered to answer these research questions with their corollary hypotheses is found in Table 2, p. 57.

**Analysis of Data**

**Research Question One:** What are the learning styles of these community college mathematics students?

1a. **H₀:** There is no difference in the mean score of field dependence-independence in students in this community college mathematics course and the mean of the norming sample.

The test used in determining field-dependence-independence is the **Group Embedded Figures Test (GEFT)** by Witkin, Oltman, Raskin, and Karp. The test has 18 complex figures within which a simpler figure is embedded. The student who is able to find a significant number of hidden figures is termed field-independent. Since field preference is a continuous distribution, the designations "field-dependent" and "field-independent" are relative.

Witkin et al. (1971) felt that the difference in the mean of field-dependence for females was significant enough to separate the scores and calculate the means according to sex. In the population used for validation, women tended to be more field-dependent than men. Since these separate means were an integral part of the norming data, the same distinction had to be made with the data of this study. Students scoring above the mean were termed field-independent while those below the mean were classified as field-dependent.
<table>
<thead>
<tr>
<th>Cognitive Style</th>
<th>Number of Students</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Experimental Mean</th>
<th>S.D.</th>
<th>Control Mean</th>
<th>S.D.</th>
<th>Total Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Style</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GEFT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>50</td>
<td>0 - 18</td>
<td></td>
<td>10.7</td>
<td>5.5</td>
<td>9.2</td>
<td>5.1</td>
<td>9.9</td>
<td>5.3</td>
</tr>
<tr>
<td>Female</td>
<td>30</td>
<td>0 - 14</td>
<td></td>
<td>8.3</td>
<td>4.0</td>
<td>6.9</td>
<td>4.0</td>
<td>7.5</td>
<td>4.0</td>
</tr>
<tr>
<td>YSLT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>80</td>
<td>1 - 22</td>
<td></td>
<td>10.9</td>
<td>4.3</td>
<td>12.5</td>
<td>4.3</td>
<td>11.7</td>
<td>4.4</td>
</tr>
<tr>
<td>Left</td>
<td>80</td>
<td>2 - 20</td>
<td></td>
<td>10.9</td>
<td>3.6</td>
<td>11.1</td>
<td>3.7</td>
<td>11.0</td>
<td>3.6</td>
</tr>
<tr>
<td>Mathematical Achievement</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>80</td>
<td>8 - 60</td>
<td></td>
<td>19.1</td>
<td>11.3</td>
<td>24.1</td>
<td>15.3</td>
<td>21.8</td>
<td>13.8</td>
</tr>
<tr>
<td>Unit test</td>
<td>80</td>
<td>20 - 100</td>
<td></td>
<td>86.6</td>
<td>11.3</td>
<td>82.9</td>
<td>16.3</td>
<td>84.6</td>
<td>14.2</td>
</tr>
<tr>
<td>Increase</td>
<td>80</td>
<td>12 - 92</td>
<td></td>
<td>67.4</td>
<td>12.5</td>
<td>38.8</td>
<td>18.8</td>
<td>62.8</td>
<td>16.6</td>
</tr>
</tbody>
</table>
The college population used by Witkin et al. (1971) found that the male score averaged 12.0 while the females had a mean score of 10.8. The means of the males and the females in the study sample were compared with the means of the norming sample and using a t-test, the probability of having a group with this mean was determined.

**TABLE 3**
Mean and Standard Deviations for Group Embedded Figures Test

<table>
<thead>
<tr>
<th></th>
<th>Norming Sample</th>
<th>Study</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean  S.D.</td>
<td>Mean  S.D.</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12.0  4.1</td>
<td>9.9   5.3</td>
<td>0.007</td>
</tr>
<tr>
<td>Female</td>
<td>10.8  4.2</td>
<td>7.5   4.0</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Since the difference in the means of the study sample and the norming population is well below a probability of 0.05, the null hypothesis may be rejected. In the more mathematically sophisticated students in the pilot study, the results were approximately the same for the males (p = 0.02), but the females were typical of the female population in the norming sample mean (p = 0.77).

1b. $H_0$: There is no significant difference in the number of field-dependent and field-independent students in this set of community college students.
TABLE 4

Number of Students in Each Category Determined by GEFT

<table>
<thead>
<tr>
<th>Dependent</th>
<th>Independent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>52</td>
<td>28</td>
<td>80</td>
</tr>
</tbody>
</table>

Since the above table constitutes discreet data, a chi-square test was used. The resultant chi-square of 7.2 was well beyond the critical value for chi-square with one degree of freedom at the 0.05 level. Hence, the null hypothesis may be rejected, and there are significantly more field-dependent than field-independent students in this community college population.

1c. $H_0$: There is no significant difference in the right (left) hemisphere dominant means of these community college mathematics students and those of the college population forming the norming sample.

There are numerous tests using complicated physical apparatus and a verbal and figures analogies test for determining whether a person uses his/her right or his/her left hemispheres in processing information. However, these tests are for administration on an individual basis and require special skills on the part of the administrator. Your Style of Learning and Thinking, Form B by Torrance, Reynolds, Ball, and Reigel (1978) is an instrument that has been validated on college students and is suitable for group use in a classroom.
In the Torrance instrument, as previously stated, the student has to decide which of the three proposed modes of acting best describes his/her usual mode of problem solving. The inventory consists of 40 of these choices and the results indicate the degree to which a student uses his/her right hemisphere or his/her left hemisphere, or a combination of both hemispheres in processing information. Since the treatment focused on the needs of the right hemisphere dominants and integrated functioning would be a combination of both right and left as well as creating a skewed cell count, the integrated category is omitted.

Using the data from the study sample, a t-test was used to compare the right and left hemisphere means with the norming parameters for Your Style of Learning and Thinking and the probability of the results was calculated.

**TABLE 5**

Means and Standard Deviations for Your Style of Learning and Thinking

<table>
<thead>
<tr>
<th>Hemisphere</th>
<th>Norming Sample</th>
<th>Study</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>S.D.</td>
<td>Mean</td>
</tr>
<tr>
<td>Right</td>
<td>11.4</td>
<td>5.0</td>
<td>11.8</td>
</tr>
<tr>
<td>Left</td>
<td>9.6</td>
<td>4.3</td>
<td>11.0</td>
</tr>
</tbody>
</table>

The study differed from the norming sample in only one of the two classifications of hemispheric dominance. It appears that these community college students are more left hemispheric dominant in
their approach to academic problems than the students tested by the authors of YSLT. This population used their right hemisphere with approximately the same consistency as those in the norming group.

It is possible to reject the hypothesis for those who prefer to use their left hemisphere and fail to reject it for those who tend to use their right hemisphere when the significance level is 0.05.

1d. \( H_0 \): There is no significant difference in the number of students dominated by right and by left hemispheric processing techniques in this set of community college students.

<table>
<thead>
<tr>
<th>TABLE 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Students in Each Category Determined by Your Style of Learning and Thinking</td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>31</td>
</tr>
</tbody>
</table>

A simple chi square analysis with one degree of freedom yields a value of 4.05 which falls into the critical region for \( p = 0.05 \). One may, therefore, reject the null hypothesis and assert that there is significant difference in the number of students who use their left and those who use their right hemisphere in this community college sample.

Research Question Two: Is there a relationship between the cognitive styles of field perceptions and hemispheric dominance?
2. \( H_0 \): There is no correlation between field perceptions and lateral hemispheric dominance in the mathematics students in this community college.

There appears to be a similarity of characteristics in those persons who are field-dependent and those whose right hemisphere dominates their thinking and also among those who are field-independent and are left hemisphere dominant. Both the field-independent and the person dominated by left hemispheric processing techniques have been known to prefer an analytic approach to problems and to deal with these same problems sequentially. On the other hand, those who are right hemisphere dominant and are field-dependent generally use a holistic or global approach to solving problems. Therefore, it would appear that there is some relationship between field-independence-left hemisphere dominance and field-dependence-right hemisphere dominance. To ascertain that such a relationship does indeed exist, a Pearson product moment coefficient was found. The following are the correlations between the scores on Witkin's Group Embedded Figures Test and the scores on Torrance's Your Style of Learning and Thinking.
TABLE 7

Correlation Between Group Embedded Figures Test and Your Style of Learning and Thinking

<table>
<thead>
<tr>
<th></th>
<th>Group Embedded Figures Test</th>
<th>Your Style of Learning and Thinking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Group Embedded Figures Test</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Your Style of Learning and Thinking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>0.30</td>
<td>1.00</td>
</tr>
<tr>
<td>Left</td>
<td>0.02</td>
<td>-0.13</td>
</tr>
</tbody>
</table>

A correlation of 0.30 would not be significant if the sample size was small. However, with 80 participants, the correlation between field perceptions and hemispheric dominance is significant at $p = 0.05$. According to these instruments, as field-independence increases, so does the tendency of these students to use right hemisphere processing techniques.

Using the Torrance test, one could reject the null hypothesis and conclude that there is some relationship between field perceptions and right hemispheric dominance. Had the theory about left hemisphere dominants and field-independents been true, there would have been a strong positive $r$ value instead of 0.02 and the right hemisphere and field-dependence correlation would have been negative.
Research Question Three: Can mathematical achievement be improved with appropriate Aptitude Treatment Interaction (ATI) based on the knowledge of the cognitive style of the learner?

3a. \( H_0: \) (Intergroup) There is no difference in mathematics achievement as evidenced by increase scores between field-dependent (field-independent) students in the experimental group and field-dependent (field-independent) students in the control group.

3b. \( H_0: \) (Intragroup) There is no difference in mathematics achievement as evidenced by increase scores between field-dependents and field-independents in the experimental group and in the control group.

To test these hypotheses, the mathematics increase scores for the respective characteristic in the experimental group were first compared with the corresponding scores in the control group. Then the results were compared within the experimental and the control groups themselves. In each case, a two sample t-test was used for this purpose.

**TABLE 8**

Comparison of Intergroup and Intragroup Mathematical Achievement Based on Increase Scores and Field Perception Classification

<table>
<thead>
<tr>
<th>Field Classification</th>
<th>Group</th>
<th>Experimental</th>
<th>Control</th>
<th>Horizontal Probability (Intergroup)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>65.6</td>
<td>57.9</td>
<td>0.02</td>
</tr>
<tr>
<td>Dependent</td>
<td>Experimental</td>
<td>65.6</td>
<td>57.9</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>70.1</td>
<td>60.8</td>
<td>0.18</td>
</tr>
<tr>
<td>Independent</td>
<td></td>
<td>70.1</td>
<td>60.8</td>
<td>0.18</td>
</tr>
<tr>
<td>Vertical Probability</td>
<td></td>
<td>0.30</td>
<td>0.66</td>
<td></td>
</tr>
<tr>
<td>(Intragroup)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In the experimental group, both categories exceeded the scores of the control classifications. The field-dependent students had significantly better increase scores in the experimental group than in the control group. When the field-independent scores are analyzed, the experimental mean is better than that in the control group but the difference did not reach a level of significance. Hence, for the intergroup analysis, one would reject the hypothesis for the field-dependent students because \( p = 0.02 \) and fail to reject it for the field-independent students because \( p = 0.18 \).

Although the field-independent students scores higher than the field-dependent students in both groups, the scope of the intragroup difference did not reach a level of significance. It is not possible, therefore, to reject hypothesis 3b.

3c. \( H_0 \): (Intergroup) There is no difference in mathematics achievement as evidenced by increase scores between right (left) hemisphere dominants in the experimental group and right (left) hemisphere dominants in the control group.

3d. \( H_0 \): (Intragroup) There is no difference in mathematics achievement as evidenced by increase scores between right and left hemisphere dominants in the experimental (control) group.

Mathematical achievement was measured by increase scores and a two sample t-test was utilized to ascertain the significance of these paired relationships.
TABLE 9
Comparison of Intergroup and Intragroup Mathematical Achievement Based on Increase Scores and Hemispheric Dominance

<table>
<thead>
<tr>
<th>Hemisphere</th>
<th>Group</th>
<th>Experimental</th>
<th>Control</th>
<th>Horizontal Probability (Intergroup)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>63.4</td>
<td>57.5</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>69.6</td>
<td>59.7</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Vertical Probability (Intragroup)</td>
<td>0.14</td>
<td>0.71</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the above calculations, it is possible to reject the intergroup hypothesis for those who indicated a predilection for using their left hemisphere since \( p = 0.02 \). The data did not support rejecting the intergroup right concept nor either of the intragroup hypotheses, experimental or control, because \( p = 0.23, 0.14, \) and \( 0.71 \) respectively.

3e. \( H_0: \) There is no difference in mathematics achievement measured by increase scores in the subgroups formed by field perceptions and hemispheric dominance in this set of community college students.

By using two cognitive characteristics to determine the subgroups, there were eight categories and hence an analysis of variance or F-test was the appropriate tool for analyzing the data.
TABLE 10
Comparison of Mathematical Achievement Increase, Field Perceptions and Hemispheric Dominance

<table>
<thead>
<tr>
<th>Field Perceptions</th>
<th>Group</th>
<th>Hemispheric Dominance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Right</td>
<td>Left</td>
</tr>
<tr>
<td>Dependent</td>
<td>Experimental</td>
<td>59.8</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>55.2</td>
</tr>
<tr>
<td>Independent</td>
<td>Experimental</td>
<td>69.2</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>62.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source</th>
<th>F-Value</th>
<th>Prob(F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fieldstatus</td>
<td>1.3</td>
<td>0.26</td>
</tr>
<tr>
<td>Group</td>
<td>3.9</td>
<td>0.05</td>
</tr>
<tr>
<td>Hemisphere</td>
<td>0.6</td>
<td>0.44</td>
</tr>
<tr>
<td>Field X Group</td>
<td>0.1</td>
<td>0.80</td>
</tr>
<tr>
<td>Field X Hemisphere</td>
<td>0.9</td>
<td>0.35</td>
</tr>
<tr>
<td>Group X Hemisphere</td>
<td>0.3</td>
<td>0.59</td>
</tr>
<tr>
<td>Field X Group X Hemisphere</td>
<td>0.0</td>
<td>0.97</td>
</tr>
</tbody>
</table>

The combination of cognitive characteristics only yielded one area of significance, namely the group to which the student had been assigned. Even in this expanded matrix, the experimental group scored better than the control group at the p = 0.05 level. The very strong achievement results from the previous hypothesis on field perceptions may have been clouded in the combination sub-
groups by the mixed outcomes from the lateral hemisphere hypotheses. It is necessary, therefore, to reserve judgment on hypothesis 3e. since the data was inconclusive.

Research Question Four: Which treatment had the greatest effect on the mathematical achievement of these community college students?

4a. $H_0$: There is no difference in mathematics achievement in the sub-groups favored by the treatment (field-dependence in the experimental group, field-independence in the control group and the sub-groups not favored by the treatment (field-independence in the experimental and field-dependence in the control group.

The treatment should have benefited the field-dependent students in the experimental classes but may have proved to be a hindrance to the field-independent students in this same group. On the contrary, the field-dependent students in the regular lecture situation probably needed the extra guidance and did not achieve as well since it was not provided. At the same time, the field-independent students in this lecture group were free to "make discoveries on their own" and should have profitted from the lack of guidance.
TABLE 11

Maximum and Minimum Treatment Effects Based on Increase Scores and Field Perceptions

<table>
<thead>
<tr>
<th>Field Perceptions</th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field-Dependent</td>
<td>65.6</td>
<td>57.9</td>
</tr>
<tr>
<td>Field-Independent</td>
<td>70.1</td>
<td>60.8</td>
</tr>
</tbody>
</table>

The total mean of the two favored groups (maximum achievement) was 63.8 and 62.0 for the other two non-favored (minimum achievement) groups, but this difference did not reach a level of significance.

F-tests serve well when main effects are being determined but when interactions are present, the outcome of tests for main effects may be clouded. In this case, the favored treatment effect was blurred by the higher scores in each of the experimental categories. This study was concerned with differences among treatments for students whose field-dependence scores were spread over the entire gamut. Cronbach and Snow (1977, p. 56) indicate that an effective method of measuring Aptitude Treatment Interaction is through the difference in regression slopes and, when this difference is greater than 0.40, it will be of practical importance.

The scattergram for the control group using gain scores and field-dependence was not linear; hence, for this regression analysis,
the unit test score was used. The following equations will be graphed on p.

Experimental  \[ y = 0.09x + 85.7 \]
Control  \[ y = 0.76x + 76.6 \]

The disordinal nature of the regression slopes is evident from their point of intersection in Figure 1, p. 71 where \( x = 13 \). Using the Cronbach and Snow regression coefficient value of 0.40 as being significant, it may be concluded that each of the regression outcomes is significantly different from the other.

Since the interaction is of practical significance, the Johnson-Neyman technique (Kerlinger and Pedhazur, 1973, p. 256) was applied to determine the region of significance. Yielding \( x_1 = 11.04 \) and \( x_2 = 14.98 \).

Unit test values (y) for students whose scores lie within the range of 11.04 and 14.98 on the field-dependence score are not significantly different across the groups. There are two regions of significance: the students scoring at or above 15 generally do better when assigned to the lecture classroom and those scoring below at or below 11 have superior achievement when the treatment prescribed was extensive guidance and a plethora of supplementary materials.

Rather than use the customary gain scores, Cronbach and Snow (1977, p. 73) advocated examining the within treatment regression of post-test on the pretest for describing and testing treatment
Scores on Group Embedded Figures Test

Fig. 1. Regression of the unit test scores of mathematical achievement on the field perception scores
effects. The equations for the regression of the unit test on the pretest follow and the graph of these equations is found in Figure 2 on p. 73.

<table>
<thead>
<tr>
<th>Group</th>
<th>Type</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental</td>
<td>Field-Dependent</td>
<td>$y = 0.5x + 76$</td>
</tr>
<tr>
<td></td>
<td>Field-Independent</td>
<td>$y = 0.15x + 85$</td>
</tr>
<tr>
<td>Control</td>
<td>Field-Dependent</td>
<td>$y = 0.35x + 73$</td>
</tr>
<tr>
<td></td>
<td>Field-Independent</td>
<td>$y = 0.22x + 80$</td>
</tr>
</tbody>
</table>

The experimental group had both the greatest (field-dependent = 0.50) and the least (field-independent = 0.15) slope. While the difference in the regression slopes did not reach Cronbach's significance level of 0.40, the range among all four was 0.35. These same coefficients are disordinal in nature but, with the exception of the field-dependent in the experimental group, the area of significance that could be determined using the Johnson-Neyman technique would have to be extrapolated beyond the empirical pretest scores.

From the graphs of the regression equations, the hypothesis is rejected. The treatment had the greatest effect on those classified as field-dependent while the milieu most suited for the field-independent students appears to be the traditional lecture mode of instruction.
Fig. 2. Regression of unit test on pretest

DE - Dependent experimental
IE - Independent experimental
IC - Independent control
DC - Dependent control
4b. $H_0$: There is no difference in the mathematics achievement in the subgroups favored by the treatment (right hemisphere dominants in the experimental group and left hemisphere dominants in the control group) and the subgroups not favored by the treatment (left-hemisphere in the experimental and right hemisphere in the control group).

For this portion, no consideration was given to the integrated group since the treatment should have no special influence on them either positive or negative.

**TABLE 12**

Maximum and Minimum Treatment Effects Based on Increase Scores and Hemispheric Dominance

<table>
<thead>
<tr>
<th>Dominant Hemisphere</th>
<th>Experimental</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>63.4</td>
<td>57.5</td>
</tr>
<tr>
<td>Left</td>
<td>69.6</td>
<td>59.7</td>
</tr>
</tbody>
</table>

Maximum Achievement Minimum Achievement

An analysis of variance technique was used to test the validity of this hypothesis yielding an $F$ ratio of 0.62. Hence, one may reject the null hypothesis.

Recent research outlines efforts made to use other methods than the traditional $F$-test for evaluating interactions. In this study an attempt was made to apply Cronbach and Snow's (1977) previously mentioned preferred technique, namely regressions, to test for interactions. Since hemispheric dominance is not determined
by a single scale but rather the forty test items identify each of three cerebral hemisphere categories, it was impossible to find a single regression of mathematical achievement on hemispheric dominance for the experimental and for the control groups. The achievement outcomes had to be compared according to cerebral preference.

The following are the equations for the regression of the unit test on the specified lateral preference.

Right Hemisphere

Experimental

$$y = -1.5x + 114$$

Control

$$y = 0.26x + 82$$

Left Hemisphere

Experimental

$$y = -1.17x + 101$$

Control

$$y = 1.6x + 58$$

Cronbach and Snow indicated that a difference in regression slopes of at least 0.40 would be considered significant. The difference for the right hemisphere dominants was 1.76 and for the left hemisphere the difference was 2.77 and so an attempt was made to find the regions of significance. The graph of both the right and the left hemisphere equations is found in Figure 3 on p. 76 and Figure 4 on p. 77.

Both pairs of equations had slopes that were disordinal and eventually they intersected at 18.1 (Figure 3) for those with
Fig. 3. Regression of unit test on right hemisphere dominance
Fig. 4. Regression of unit test on left hemisphere dominance
right hemisphere tendencies and at 15.6 (Figure 4) for their contralateral peers. In all of the subsequent discussion, it is essential to remember that these points of intersection are at least one standard deviation above their respective means.

Using the Johnson-Neyman formula, the regions of significance occur for right hemisphere dominants when \( x = 16.1 \) and 19.5. It suggests that the student scoring below 16 on YSLT would profit most in the control milieu, while those above 19.5 would achieve more in the experimental situation. The mathematics achievement of those whose score is between 16 and 20 is not profoundly influenced by either treatment.

For those who favor their left hemisphere, the demarcation region occurs below 14.4 and above 16.4. Viewed from this perspective, these left hemisphere equations imply that the more the student is dominated by left hemisphere processes the more apt he/she is to survive in a lecture situation.

In the regression of the unit test on the pretest as suggested by Cronbach and Snow, the maximum coefficient (0.44) occurred for the right hemisphere dominant students in the experimental group and the minimum of 0.14 was associated with the right hemisphere dominants in the control group.

If one uses the preceding regression analysis instead of the earlier F-tests, one may infer that strong right hemisphere dominants
are suited to the alternatives of this study while the pre-
dominantly left hemisphere students function better in the lecture
classroom. Earlier comments on the subjective nature of YSLT and
its tenuous results should be recalled when rejecting the hypothesis.

Summary

In this chapter, the hypotheses of the exploratory study
were examined and evaluated. Some of the outcomes such as the
extent of field-dependence and the effectiveness of the treatment
on the level of mathematical achievement were significant but
others, such as the relationship between field perceptions and
left hemispheric dominance, were so negligible that there was not
enough evidence from which to draw specific conclusions. Chapter V
will include a discussion of the results presented in this chapter.
Suggestions for further research will also be included there.
CHAPTER V

DISCUSSION OF RESULTS, CONCLUSIONS, AND RECOMMENDATIONS FOR FUTURE RESEARCH

This chapter summarizes the conclusions of the dissertation as they relate to the four research questions chosen for study. Drawing upon these conclusions, the chapter also offers some suggestions for further research and study.

The literature suggested that community college students had different characteristics from those of their peers in the four year college or university. The students participating in this study bore the well researched characteristics of community college students nationally, i.e. more maturity, different academic background and diverse cultural heritage. The study was unique in that it looked at a virtually untapped area of research, namely the cognitive styles of field perceptions and hemispheric dominance and the effect of appropriate aptitude treatment on the level of mathematical achievement, especially as it relates to community college students.

The major bases for the study were the four research questions established by the author.

1. What are the learning styles of these community college mathematics students?
2. Is there a relationship between the cognitive styles of field perceptions and hemispheric dominance?
3. Can mathematical achievement be improved with appropriate Aptitude Treatment Interaction (ATI) based on the knowledge of the cognitive style of the learner?

4. Which treatment had the greatest effect on the mathematics achievement of these community college students?

The scenario of the design of the study, the implementation of its procedures and the descriptive statistics of the experiment have already been detailed.

**Results of the Study**

Utilizing the data collected in this exploratory study, an attempt will now be made to answer the four research questions.

**Research Question One:** What are the learning styles of these community college mathematics students?

Only two cognitive styles were studied in this experiment. In the first of these styles, field-dependence-independence, the students in this sample are far more field-dependent than those in the norming sample ($p = 0.007$). In the more mathematically advanced precalculus students in the pilot study, the males are significantly more field-dependent ($p = 0.02$) but the female mean is approximately the same ($p = 0.77$) as that of the women in the standardized data. It should be observed that in both studies the males outnumber the females: 69 percent male in the pilot and 62 percent in the study.
It is not clear from this present data whether the mathematics students in these two studies who persevere become more field-independent or whether only the more field-independent persevere, since the means for the GEFT are noticeably higher in the precalculus pilot study than the means of the individuals in the lower level elementary algebra classes.

Not only is the extent of field-dependence greater but also the number of students possessing this characteristic is significantly larger than those who are field-independent.

The second cognitive characteristic that is the center of focus is hemispheric dominance. The quantity and quality of left hemisphere use is significantly greater than that of right hemisphere use. There are more students who think they use their left hemisphere than those who think they use their right, and the degree to which students prefer to use their left hemisphere is greater than that of the college students in the norming sample. However, it is necessary to recall the fact that these are students in a mathematics class who may possibly have developed more left hemisphere processing techniques than their peers in another discipline requiring more general hemispheric specialization. It is also possible that this left lateral preference may stem from previous educational experience. Traditionally, the schools have encouraged an almost exclusive use of the left hemisphere.
The small sample used in this study does not warrant generalizing about others outside of this community college setting. However, from the evidence presented in this study one could assert that this set of community college mathematics students are field-dependent and dominated by their left hemisphere in processing information.

Research Question Two: Is there a correlation between field perceptions and lateral hemispheric preference in processing information?

The characteristics of those identified as field-dependent and right hemisphere dominant, as field-independent and left hemisphere dominant appear to be similar (Witkin et al., 1971; Torrance et al., 1978; Wheatley et al., 1978). If these learning styles are related as implied by their characteristics, then there should be a positive correlation for the left hemisphere and the field perception scores and a negative correlation for the right hemisphere and field perception scores.

The only significant correlation found in this sample (r = 0.30) appears to indicate that the more field-independent the subjects, the more they depend on their right hemisphere when reasoning out a reply or solving a problem. Hence, the data does indicate that a relationship exists, but the correlation is contrary to the theoretical expectations. When pondering this adverse outcome, one must recall the previously discussed subjectivity factor of YSLT
Research Question Three: Can mathematical achievement be improved with the appropriate Aptitude Treatment Interaction based on the knowledge of the cognitive style of the learners?

In both the pilot and the main studies, the mathematical achievement level of the experimental group is higher than that of the control group. When the students were classified as field-dependent or field-independent, the intergroup achievement difference is significantly better ($p = 0.02$) for the field-dependents in the experimental sections, but there is no noteworthy difference for the field-independents. Intergroup classifications for hemispheric dominance show significantly higher achievement levels only for the left hemisphere dominants ($p = 0.02$).

The intragroup analysis does not reach a noteworthy probability level. Likewise, when two cognitive characteristics are combined to form four subgroups i.e. field-dependent right, field-dependent left, field-independent right, and field-independent left, the only category that yields a significant F-ratio is the group classification. In other words, being in the experimental group does make a difference in the mathematical achievement of these students.
Research Question Four: Which treatment had the greatest effect on the mathematical achievement of these community college students?

The first comparison utilized is the difference in the combined increase means of the subgroups expected to have maximum achievement (field-dependent experimental, field-independent control) and the subgroups expected to have minimum achievement (field-independent experimental, field-dependent control). This same process is also repeated for the lateral hemisphere subgroups. In neither of the two t-tests is the result significant. However, Cronbach and Snow (1977) feel that a better way to judge interactions is, through the use of regressions.

When the regression lines are analyzed using field perceptions as the independent variable and the unit test as the dependent variable, the slopes of the lines (see figure 1) show that the field-dependents profited most by the treatment in the experimental classes and the field-independent students manage very well in the lecture classroom. Using a different independent variable, the pretest, in the regression analysis, it is observed that students classified as field-dependent in the experimental group have the greatest slope for the regression equation. From this, one may infer that of all of the four subgroups (see figure 2), the students who are classified as field-dependent and were treated by the mode of instruction of the experimental group achieve best.
For hemispheric dominance, the entire experimental group could not be placed on a single continuum for the regression analysis since the one test identified two distinct characteristics: right or left hemispheric dominance. Hence, the right hemisphere regression for the experimental group had to be compared to the right hemisphere scores for the control category and similarly for the left hemisphere.

For both the right and the left hemisphere, the regression equation has more than the significant difference in coefficients of 0.40 (Cronbach and Snow, 1977). Using the Johnson Neyman formula suggests that students who rely heavily on their right hemispheres (see figure 3) fare best in the experimental section. This outcome is consonant with the theory that the more right hemisphere dominant the students, the more they need visual and spatial aids in the educational setting. It should be noted again that the regression analysis differs from the outcome using the t-test. As indicated earlier, Cronbach and Snow feel that interactive effects are lost in using the latter test and this ambiguous outcome may be one such example.

A similar pattern emerges from the left hemisphere regressions in that the region of positive significance is in favor of the traditional method. As student scores increase above 15 on the left hemisphere values of the Torrance test, the better these students achieve in a typical lecture situation (see figure 4).
This finding is in line with the theories (Hunter, 1976; Samples, 1975) that traditional education has favored the student who prefers using his/her left hemisphere.

When using the regression of the unit test on the pretest, the differences in the regression coefficients are not significant. However, their magnitude does support the outcomes in the preceding lateral hemisphere analysis. The slope is maximum (0.44) for right hemisphere dominants in the experimental classes and minimum (0.14) for right hemisphere dominants in the control classes.

Judging from the previous discussion, research question four cannot be answered directly since there is no one best treatment for all cognitive styles. The response, therefore, has to be divided according to what is the best treatment for students with a particular cognitive style.

For the field-dependent persons, all tests indicate that they attained higher mathematical levels in the experimental sections. The field-independents inevitably scored higher than the field-dependents, and those on the upper end of the field-independence scale had an advantage in the lecture sections.

There are mixed results on the lateral hemispheric preference analyses. T-tests on the mathematical achievement means favor the left hemispheric dominants in both the experimental and the control categories. However, regression analysis of the unit test results on either the right or the left hemisphere scores yields a different
picture. Students who are extremely dependent on either of the two hemispheres appear to perform best in two different educational modes. In this instance, those who rely strongly on their right hemisphere achieve best in the experimental mode; while those who are strongly left dominant are suited for the control or lecture classroom.

**Conclusions**

In most previous attempts to individualize instruction, attention was generally focused on varying the pace. An effort was made in this study to expand the alternatives in supplementary materials and alter the mode of presentation while still teaching the same subject. This study has emphasized the necessity of being flexible in developing strategies for problem solving that are cognizant of factors of the learner's problem solving habits.

The students probably have not changed since it is expected, from the literature, that cognitive processing of young adults is fairly well crystallized and difficult to discard. In addition, two weeks is not a sufficient period to effect a lasting change. Had the students been younger, the results might be different in this regard. Primary grade pupils who are low on spatial differentiation are still malleable enough so that the teacher can effectively tailor experiences to improve his/her spatial discrimination.
Some of the specific conclusions derived from this research are:

1. Among the community college students participating in this study, there are more field-dependent than field-independent students and these individuals are more field-dependent than the average college students. Since these students are more field-dependent, the mode selected for their instruction should either compensate for, capitalize on, or challenge their particular cognitive style. In many disciplines, it may be possible to develop procedures and/or courses which do not need the skills that the students lack, thus compensating for their deficiencies—especially if their career choice does not require the missing skill. This study capitalizes on the fact that the student who is field-dependent needs extensive guidance and interaction with other people. It provides far more individual attention on the part of the instructor, and it also supplies a comfortable arrangement for peer interaction in the Learning Center. Should the field-dependent person wish to pursue a career in mathematics or some related scientific discipline, it would probably be advisable to challenge the individual to develop flexibility in the approaches
he/she uses to learning and encourage the student to acquire rarely used skills—in this case more field-independence.

2. Among the participants, there were more who tended to use their left rather than their right hemisphere, and the level of use was significantly higher than that of the students in the norming sample. The lecture classroom is satisfactory for students with this cognitive style. However, the other 39 percent who are more inclined to use their right hemisphere must be considered in educational planning and hence the need for academic alternatives.

The achievement edge given to the left hemisphere dominants, while characteristic of adults, may also have been related to the nature of elementary mathematics and its dependence on the computational left portion of the brain. Results might have been even more skewed in favor of the left if the treatment had not been prescribed in favor of the right hemisphere students. It is also possible that students in other courses, like art, which require visual and spatial skills may possess a higher level of right hemisphere use. Cultural influences must likewise be considered since elementary and secondary
education often emphasizes left hemisphere skills.

3. It will be noted that the students in both field perceptions and hemispheric dominance experimental subgroups achieve higher mathematical levels than their peers in the corresponding control subgroups. The latter had the usual three lectures a week, which was disastrous to the field-dependent student and to the one who is identified as being right hemisphere dominant.

Based on the above outcome and the results of the regression analysis, it appears that, excluding the extreme upper limits of the field-independent and left hemisphere dominant scales, most of the mathematics students at this community college would profit from the assistance provided by the use of additional visual and spatial aids in the regular classroom and by the numerous optional materials and the constructive, more personalized atmosphere of the Learning Center sessions. All of this can be accomplished with no additional class time.

Suggestions for Further Research

Since the study was exploratory in nature and sampled a population that was more mature than is customary in educational research and since the topic of cognitive styles is both vast and relatively young in psychological circles, the possibilities for
further examination are boundless. Among those possibilities are:

1. The use of cognitive styles in an educational context is relatively new and there are very few instruments for determining specific styles. The primary need, therefore, is for a validated, non-preferential instrument that can be utilized to measure which cerebral hemisphere an individual favors. This instrument must be uncomplicated enough to be administered on a group basis by teachers in an ordinary classroom.

2. When such an instrument for measuring hemispheric dominance is available, the interaction of presentation suited to each hemisphere and the level of achievement could be replicated.

3. The study would profit by being replicated using a larger sample and by sampling students in other disciplines.

4. Some of the other well researched cognitive styles could be studied to determine whether or not they are more applicable to community college students than field-perceptions and hemispheric dominance. A few other cognitive styles have been tested on community college students but most research has concentrated on younger subjects.
5. A longitudinal study could be undertaken which might examine whether a field-independent student chose to take advanced mathematics courses or whether the student taking mathematics courses becomes more field-independent.

6. Although not directly related to this study, it was observed that those who drop out of the mathematics classes before the end of the semester in both the pilot and the main study were field-dependent persons. Additional research on this relationship and the intervention of an appropriate treatment might help the field-dependent individuals continue their education and, at the same time, it could possibly reduce the relatively high attrition rate in most community colleges.

Concluding Statement

An intent of this dissertation was to draw attention to the fact that despite a long history of continued use in universities, the lecture method may not be the most effective educational alternative for that latest arrivals on the American campuses - the community college students. The diverse backgrounds that these young and not so young adults bring to the classroom may
be not so much the product of their previous educational experiences but rather the result of the processes by which these individuals acquire information. The relatively new research on information processing known as cognitive style is just beginning to move from the psychologist's couch to the educator's planning desk. It is a task that appears rich in promise. Cronbach and Snow (1977, p. 493) very aptly express it:

The substantive problem before us is to learn which characteristics of the person interact dependably with which features of the instructional method. This is a question of awesome breadth. In principle, it calls for a survey of all the ways in which people differ. It requires that individuality be abstracted into categories or dimensions. Likewise it calls for abstractions that describe instructional events in one classroom after another.

Truly, this is an awesome task with an apparently long period of research ahead that should eventually lead to valid deductions about the relationship of cognitive style and the modes of academically assisting not only the community college students but learners of all other levels as well. Cognitive styles and the use of them in aptitude treatment interactions is, indeed, an idea whose time has come.
LIST OF REFERENCES


Austin, James H. "Eyes Right: Eyes Left:" Saturday Review, August 9, 1975, p. 32.


Maxwell, Martha. "The Under-Prepared College Student in Mathematics." University of California, 1977. (Mimeographed.)


Sperry, Roger W. "Left-Brain, Right-Brain." Saturday Review, August 9, 1975, pp. 30-33.


Tobias, Shelia. Wellesley College-Wesleyan University Mathematics Project. September, 1977. (Mimeographed.)


APPENDIX A

Mathematical Pretest
MAT 121

Chapter 7 Pretest

1. Insert the appropriate symbol ($>$, $=$, $<$)
   a. $4 \quad 7$
   b. $5 \quad -3$
   c. $-2 \quad -4$
   d. $7 + 3 \quad 4(2)$
   e. $x \cdot x \quad x^2$

2. Given that $6 \leq 8$, state the inequality obtained when both sides are multiplied by $-3$.

Use the properties of inequalities to simplify the following statements. (#3 - #5)

3. $x - 8 \leq 8$

4. $1 \leq 2x - 3 \leq 13$

5. $\frac{x + 4}{5} < 3$

6. Graph the solution set of: $5x + 3 \geq 3x + 7$

7. Graph the solution set of: $|2x - 5| \leq 11$
8. Graph: \( \{ x \mid x < -3 \} \cup \{ x \mid x > 4 \} \)

9. Graph the solution set of \( \{ (x, y) \mid x + 2y < 4 \} \)

10. Graph the solution set of the system:

\[ \{ (x, y) \mid x + y \geq 3 \} \]
\[ \{ (x, y) \mid 2x - y < 6 \} \]
\[ \{ (x, y) \mid y \leq 5 \} \]
APPENDIX B

Behavioral Objectives of the Unit
LINEAR INEQUALITIES

You should be able to:

I. A. Determine the position of a positive, negative or zero value on the number line.
   B. Tell in which direction a point moves if it is "increasing" or if it is "decreasing".
   C. Compare real numbers (>, <)

II. A. Add the same number to both sides of an inequality.
      B. Multiply or divide both sides of the inequality by the same positive number.
      C. Multiply or divide both sides of the inequality by the same negative number.

III. A. Identify the solution set of an inequality.
        B. Graph the solution set of the inequality on the real number line.

IV. A. Define absolute value.
       B. Recognize, solve and graph $|x|<a$ as the intersection of two sets.
       C. Recognize, solve and graph $|x|>a$ as the union of two sets.

V. A. Graph an inequality in two variables in the plane.
     B. Graph systems of linear inequalities in the plane.
APPENDIX C

Unit Test of Mathematical Achievement
MAT 121 Chapter 7

Point Values

<table>
<thead>
<tr>
<th>#1 - #10</th>
<th>11 - 13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 points each</td>
<td>5 points each</td>
<td>20 points</td>
</tr>
</tbody>
</table>

1. Insert the appropriate symbol (>, =, <)
   a. -4     -6
   b. 7     0
   c. -3     0
   d. (-5)(1) -7 + 2
   e. (-2)(-3) -8

2. Given that $3 \leq 7$, state the inequality obtained when -7 is added to each side.

3. Given that $8 > 6$, state the inequality obtained when both sides are multiplied by -3.

4. Given that $9 > 4$ and $4 > x$, state the inequality relating to 9 and x.

Solve for s: (#5 - #7)

5. $3x + 4 \leq 2x - 6$

6. $2(x - 3) \geq 3(x + 1)$

7. $x + \frac{1}{4} \leq 2x = \frac{5}{4}$
Graph the solution: (#8 - #14)

8. \(3x + 4 \geq 2x + 5\)

9. \(\{x \mid x < 2\} \cup \{x \mid x > 2\}\)

10. \(\{(x, y) \mid y \leq -2\}\)

11. \(3 \leq x + 2 \leq 7\)

12. \(|x - 3| \leq 5\)
13. \[ \{(x, y) \mid x + y \geq 5\} \] 

14. \[ \{(x, Y) \mid 2x - y \leq 3\} \]
\[ \{(x, y) \mid x + y \leq 6\} \]
\[ \{(x, y) \mid x \geq -1\} \]
APPENDIX D

Your Style of Learning and Thinking

Form B

P. Torrance, C. Reynolds, O. Ball and T. Riegel

Permission to use this instrument was given by the senior author, Paul E. Torrance Ph.D., in a phone conversation on August 6, 1978.
YOUR STYLE OF LEARNING AND THINKING

INSTRUCTIONS: People differ in their preferred ways of learning and thinking. On the answer sheet provided, describe your style of learning and thinking by blackening the appropriate blanks. In each item, three different styles of learning or thinking are described. Select the one that describes most accurately your strength or preference.

1. a) not good at remembering faces  
   b) not good at remembering names  
   c) equally good at remembering names and faces

2. a) respond best to verbal instructions  
   b) respond best to instruction by example  
   c) equally responsive to verbal instruction and instruction by example

3. a) able to express feelings and emotions freely  
   b) controlled in expression of feelings and emotions  
   c) inhibited in expression of feelings and emotions

4. a) playful and loose in experimenting (in sports, art, extra curricular activities, etc.)  
   b) systematic and controlled in experimenting  
   c) equal preference for playful/loose and systematic/controlled ways of experimenting

5. a) prefer classes where I have one assignment at a time  
   b) prefer classes where I am studying or working on many things at once  
   c) I have equal preference for the above type classes

6. a) preference for multiple-choice tests  
   b) preference for essay tests  
   c) equal preference for multiple-choice and essay tests

7. a) good at interpreting body language or the tone aspect of verbal communication  
   b) poor at interpreting body language; dependent upon what people say  
   c) equally good at interpreting body language and verbal expression
8. a) good at thinking up funny things to say and/or do
   b) poor at thinking up funny things to say and/or do
   c) moderately good at thinking up funny things to say or do

9. a) prefer classes in which I am moving and doing things
   b) prefer classes in which I listen to others
   c) equal preference for classes in which I am moving and doing things and those in which I listed

10. a) use factual, objective information in making judgments
    b) use personal experiences and feelings in making judgments
    c) make equal use of factual, objective information and personal experiences/feelings in making judgments

11. a) playful approach in solving problems
    b) serious, all-business approach to solving problems
    c) combination of playful and serious approach in solving problems

12. a) mentally receptive and responsive to sounds and images more than to people
     b) essentially self acting and creative mentally with groups of other people
     c) equally receptive and self acting mentally regardless of setting

13. a) almost always am able to use freely whatever is available to get work done
    b) at times am able to use whatever is available to get work done
    c) prefer working with proper materials, using things for what they are intended to be used for

14. a) like for my classes or work to be planned and know exactly what I am supposed to do
     b) like for my classes or work to be open with opportunities for flexibility and change as I go along
     c) equal preference for classes and work that is planned and those that are open to change

15. a) very inventive
    b) occasionally inventive
    c) never inventive

16. a) think best while lying flat on back
    b) think best while sitting upright
    c) think best while walking or moving about
17. a) like classes where the work has clear and immediate applications (e.g., mechanical drawing, shop, home economics)
b) like classes where the work does not have a clearly practical application (literature, algebra, history)
c) equal preference for the above type of classes

18. a) like to play hunches and make guesses when I am unsure about things
b) rather not guess or play a hunch when in doubt
c) play hunches and make guesses in some situations

19. a) like to express feelings and ideas in plain language
b) like to express feelings and ideas in poetry, song, dance, etc.
c) equal preference for expressing feelings and ideas in plain language or in poetry, song, dance, etc.

20. a) usually get many new insights from poetry, symbols, etc.
b) occasionally get new insights from poetry, symbols, etc.
c) rarely ever get new insights from poetry, symbols, etc.

21. a) preference for simple problems
b) preference for complex problems
c) equal preference for simple and complex problems

22. a) responsive to emotional appeals
b) responsive to logical, verbal appeals
c) equally responsive to emotional and verbal appeals

23. a) preference for dealing with one problem at a time
b) preference for dealing with several problems at a time
c) equal preference for dealing with problems sequentially or simultaneously

24. a) prefer to learn the well established parts of a subject
b) prefer to deal with theory and speculations about new subject matter
c) prefer to have equal parts of the two above approaches to learning

25. a) preference for critical and analytical reading as for a book review, criticism or movie, etc.
b) preference for creative, synthesizing reading as for making applications and getting information to solve problems
c) equal preference for critical and creative reading
26. a) preference for intuitive approach in solving problems  
b) preference for logical approach to solving problems  
c) equal preference for logical and intuitive approaches to solving problems  

27. a) prefer use of visualization and imagery in problem solving  
b) prefer language and analysis of a problem in order to find solutions  
c) no preference for either method  

28. a) preference for solving problems logically  
b) preference for solving problems through experience  
c) equal preference for solving problems logically or through experience  

29. a) skilled in giving verbal explanations  
b) skilled in showing by movement and action  
c) equally able to give verbal explanations and explanations by action and involvement  

30. a) learn best from teaching which uses verbal explanation  
b) learn best from teaching which uses visual presentation  
c) equal preference for verbal explanation and visual presentation  

31. a) primary reliance on language in remembering and thinking  
b) primary reliance on images in remembering and thinking  
c) equal reliance on language and images  

32. a) preference for analyzing something that has already been completed  
b) preference for organizing and completing something that is unfinished  
c) no real preference for either activity  

33. a) enjoyment of talking and writing  
b) enjoyment of drawing and manipulating objects  
c) enjoyment of both talking/writing and drawing/manipulating  

34. a) easily lost even in familiar surroundings  
b) easily find directions even in strange surroundings  
c) moderately skilled in finding directions  

35. a) more creative than intellectual  
b) more intellectual than creative  
c) equally creative and intellectual
36. a) like to be in noisy, crowded places where lots of things are happening at once  
   b) like to be in a place where I can concentrate on one activity to the best of my ability  
   c) sometimes like both of the above and no real preference for one over the other  

37. a) primary outside interests are aesthetically oriented, that is, artistic, musical, etc.  
   b) primary outside interests are primarily practical and applied, that is, working, team sports, cheerleading, etc.  
   c) participate equally in the above two types of activities  

38. a) vocational interests are primarily in the general areas of business, economics, and the hard sciences, i.e. chemistry, biology, physics, etc.  
   b) vocational interests are primarily in the general areas of the humanities and social sciences, i.e., history, sociology, psychology, etc.  
   c) am undecided or have no preference at this time  

39. a) prefer to learn details and specific facts  
   b) prefer a general overview of a subject, i.e., look at the whole picture  
   c) prefer overview intermixed with specific facts and details  

40. a) mentally receptive and responsive to what I hear and read  
   b) mentally searching, questioning, and self-initiating in learning  
   c) equally receptive/responsive and searching/self-initiating
APPENDIX E

Description and Analysis of Lateral Eye Movement Test
Lateral Eye Movement Test

When the subjective nature of the Torrance instrument, *Your Style of Learning and Thinking*, (YSLT) was questioned during the pilot study, a lateral eye movement (LEM) test was attempted to see if a different outcome was possible. The students were videotaped while responding to 10 questions. The first 3 questions would ordinarily activate the right hemisphere, the next 3 the left hemisphere and the last 4 would involve both hemispheres. (see Appendix F). The direction of the first eye movement after the completion of the question was recorded and the number of movements in any direction varied from 0 to 10. Looking vertically or straight ahead was classed as invalid. (One student never moved an eye muscle throughout the short typing session).

Only 60 of the 80 participants (75 percent) agreed to be videotaped. In 3 cases, the students were asked 11 questions instead of 10. There are no standards against which to compare the results, although, as previously discussed in Chapter II, there has been considerable research on validity and on the implications of a person's eye movements. The following data was collected from the videotaping analysis.
TABLE 13

Mean and Standard Deviation for the Lateral Eye Movement Test

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This data does not appear to have any significance since there was no mean score which indicated a dominant hemisphere and the standard deviations are unrealistic in view of the maximum score of 10.

The lateral eye movements were then compared to the results of the Torrance instrument using a Pearson product moment correlation coefficient. In examining the data it should be recalled that lateral brain activity is contralateral to the direction of the eye movement.

TABLE 14

Correlation between YSLT and LEM Scores

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<th>Your Style of Learning and Thinking</th>
<th>Lateral Eye Movements</th>
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The negative correlations, although not significant, indicate that as the Torrance instrument scored the student as increasingly right hemisphere dominant, the lateral eye movement score indicated decreasing use for the same hemisphere. The positive correlations in the table 14 point to the fact that as the right hemisphere supremacy increases in the Torrance scale, the lateral eye movement test indicates that it is the left that is increasing. Hence, there appear to be opposite outcomes from two instruments which are supposedly measuring the same construct. These correlation coefficients are almost identical to those found in the pilot study.

When the conflicting correlations become evident, no attempt was made to evaluate mathematical achievement using hemispheric dominance based on the lateral eye movement test as the criterion for forming the subgroups. The contradictory outcomes found in these two tests, that should be measuring the same cognitive style, highlight the need for an objective, convenient instrument for assessing lateral hemispheric dominance.
APPENDIX F

Lateral Eye Movement Questions
(Conjugate) Lateral Eye Movement Test

Directions: Make sure that the student is facing the camera and that the videotape operator is ready. Ask the student three questions from both Group I and Group II and four questions from Group III. Remember the answer is not the important issue.

Group I

1. How many letters are there in the word Washington? or Fitchburg? or Gardner?
3. What is meant by the proverb "It is better to have a bad peace than a good war"?
4. Make up a sentence using two forms of the verb "have".
5. Define the word "economics". or "sociology". or "political science".
6. What adjective applies to the nouns: sky, ocean, eyes, jeans?
7. How many "i's" are there in Mississippi?

Group II

8. There is a profile of George Washington on a quarter. Which way does he face?
9. Imagine a rectangle. Divide it in half by drawing a line from the upper left to the lower right. What figures do you have?
10. Try to picture all the doors in your house and tell me how many doorknobs there are.
11. Hum "Row, Row, Row Your Boat" or "Down by the Old Mill Stream".
12. When you enter this building from the back parking lot, Which way do you turn to go to the library? the bookstore?
13. How many levels are there in the MWCC library?
Group III

14. If you were President, how would you deal with the Egyptian-Palestine question?

15. Do you think that the legislators will solve problems by changing the drinking age back to 21?

16. If you could be the boss at your job, what changes would you make?

17. If you could afford to buy any car that you wished, what kind would you buy? Why?

18. What do you think should be done to stabilize the economy?

19. What can the Student Council do to improve student life here on campus?

20. Do you think that the energy crisis is real? Why?

21. What do you think prompted the people in Guyana to commit mass suicide?

The above questions originated from the following sources:

1. Austin (1975) - Numbers 3 and 6.

2. Bakan (1971) - Numbers 1, 2, 3, and 14.

3. Kocel, Galin, Ornstein and Merrin (1972) - Numbers 2, 4, 5, 8, 9, 10, 11, and 14.

4. Original but based on suggestions in the literature and events current at the time of the videotaping. Numbers 12, 13, 15 - 20.
APPENDIX G

Student Consent Form
Dear Student,

This semester, a small experiment will be conducted with some of the MAT 120, Introduction to Mathematics I, classes to determine, if possible, how students learn mathematics. During the course of the semester:

1. Some tests on learning styles and mathematics achievement will be administered.
2. Some students will spend part of their scheduled class time in the Learning Center.
3. Some students will agree to being videotaped.

The information from these tests and from the videotape will only be used to obtain group data and at no time will any of the student's individual scores be identified personally. The data will not be reflected in your grade nor in your personal file.

Would you please complete the attached form.

Gratefully,
_____ I am willing to have the personal data outlined on the previous page used for the purposes stated.

_____ I am unwilling to have the personal data outlined on the previous page used for the purposes stated.

I am willing to have the videotape viewed by professional educators without my name attached. (No name was fully used in the taping.)

Yes _____ No _____ I was not videotaped _____

Date ____________________ Signed ____________________
APPENDIX H

Individual Data on Each Student
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Table 16 - Experimental Group
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