MONTANA STATE UNIVERSITY

The effects of matching learning materials with students preferred learning styles upon mathematical academic achievement and attitudes

by Joyce Westgard Bryant

A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Education
Montana State University
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Abstract:
The problem of this study was to determine, for seventh grade mathematics students of Bozeman Junior High School, Bozeman, MT, the effects of matching learning materials with students' preferred Learning Styles upon Mathematical Academic Achievement and Mathematical Attitude when compared to a control group during a two-week unit on graphs and statistics.

This problem also included a study of any effects of Mathematical Academic Achievement or effect in Mathematical Attitude between the genders and among Socio-economic Status groups due to the experimental treatments.

The Pilot Study was completed in 1988; the Investigative Study in 1989. Learning style preference treatment groups were determined by the Gregorc Style Delineator. The Aiken-Dreger Math Attitude Scale, and the MAT Graphs and Statistics Instructional Test were administered on a Pre-Post Test basis.

Inspection of the data revealed the following findings based on ANOVA and Chi-square statistical analyses: None of the hypotheses for the Control Groups were found to be significant at the .05 level. Experimental Group significant differences were found for Mathematical Achievement Groups ($p \leq .006$) and for Learning Styles ($p \leq .012$) for the dependent variable Mathematical Attitude. Post-hoc Scheffe' Analyses located no pairs of groups for either difference significant at the .05 level. All Low and Medium Mathematical Achievement Groups revealed positive attitude growth for all Learning Styles. The High Mathematical Achievement Group revealed positive attitude growth only for the Abstract Random Learning Style.

The following groups of students, then, benefit with a more positive Mathematical Attitude by the use of matching teaching materials to their learning styles in the classroom: 1) Students with Low Mathematical Achievement Change, and all Learning Styles; 2) Students with Medium Mathematical Achievement Change, and all Learning Styles; 3) Students with High Mathematical Achievement Change and Abstract Random Learning Style.

Further study should be conducted to define the effects of grouping Gender, Socio-economic Status groups, Achievement and Attitude Groups and matching teaching materials to student preferred Learning Styles.

THE EFFECTS OF MATCHING LEARNING MATERIALS WITH STUDENTS' PREFERRED LEARNING STYLES UPON MATHEMATICAL ACADEMIC ACHIEVEMENT AND ATTITUDES

by
Joyce Westgard Bryant

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APPROVAL

of a thesis submitted by

Joyce Westgard Bryant

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

4/25/89
Date

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5-1-89
Date

Head, Major Department

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Date May 19, 1989

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ABSTRACT

The problem of this study was to determine, for seventh grade mathematics students of Bozeman Junior High School, Bozeman, MT, the effects of matching learning materials with students' preferred Learning Styles upon Mathematical Academic Achievement and Mathematical Attitude when compared to a control group during a two-week unit on graphs and statistics. This problem also included a study of any effects of Mathematical Academic Achievement or effect in Mathematical Attitude between the genders and among Socio-economic Status groups due to the experimental treatments.

The Pilot Study was completed in 1988; the Investigative Study in 1989. Learning style preference treatment groups were determined by the Gregorc Style Delineator. The Aiken-Dreger Math Attitude Scale, and the MAT Graphs and Statistics Instructional Test were administered on a Pre-Post Test basis.

Inspection of the data revealed the following findings based on ANOVA and Chi-square statistical analyses: None of the hypotheses for the Control Groups were found to be significant at the .05 level. Experimental Group significant differences were found for Mathematical Achievement Groups ($p \leq .006$) and for Learning Styles ($p \leq .012$) for the dependent variable Mathematical Attitude. Post-hoc Scheffe' Analyses located no pairs of groups for either difference significant at the .05 level. All Low and Medium Mathematical Achievement Groups revealed positive attitude growth for all Learning Styles. The High Mathematical Achievement Group revealed positive attitude growth only for the Abstract Random Learning Style.

The following groups of students, then, benefit with a more positive Mathematical Attitude by the use of matching teaching materials to their learning styles in the classroom: 1) Students with Low Mathematical Achievement Change, and all Learning Styles; 2) Students with Medium Mathematical Achievement Change, and all Learning Styles; 3) Students with High Mathematical Achievement Change and Abstract Random Learning Style.

Further study should be conducted to define the effects of grouping Gender, Socio-economic Status groups, Achievement and Attitude Groups and matching teaching materials to student preferred Learning Styles.

CHAPTER 1

PROBLEM, NEED AND DEFINITIONS OF TERMS USED

Introduction

Early educational philosophers since the time of Plato and Socrates have relied heavily on introspection and personal experience. By the end of the last century a large amount of evidence on thought processes had been accumulated. Recent research in education has added to that evidence in areas that include learning, learning style, attitudinal change, and increased academic achievement (Bigge, 1982; Good, 1983).

The research on learning indicates that learning should not be simply a passive process of absorbing knowledge, but should involve many activities which include memorizing, relating new information to old, linking theoretical ideas to personal experience, and evaluating evidence (Gregorc, 1977; Entwistle, 1981). The emphasis on intellectual aims does not imply a lack of interest in non-cognitive factors associated with learning. Recognizing individual differences in personality and motivation is also important, for differences in personality affect our preferred ways of learning (Curry, 1987). People differ much in intellectual abilities, attitudes, and personality and adopt characteristically different approaches to learning. This general tendency to adopt a particular approach to learning is referred to as a learning style (Dunn, 1978).

Statement of the Problem

One of the most important areas of learning style research is the investigation of the effects of matching and mismatching teaching materials with students' learning styles (Gregorc, 1977; Dunn, 1978; Schenker, 1981; Olsen, 1983; Griffin, 1984; Harmon, 1984; Rodriguez, 1985; Hodges, 1985). Research has shown inconsistent findings when teaching materials have been matched with the preferred learning styles of students. It is on the effects of matching learning materials with students' preferred learning styles upon mathematical academic achievement and attitudes that this study was centered.

The problem of this study was to determine, for seventh grade mathematics students of the Bozeman Public Schools, the effects of matching learning materials with students' preferred learning styles upon mathematical academic achievement and attitudes when compared to a non-treatment group during a two-week unit on graphs and statistics. This problem also included a study of any changes of mathematics achievement or change in attitude between the genders and among socio-economic status groups due to the experimental treatments.

Need of the Study

Theories are advanced to explain facts already collected, to predict future events, and to guide experimentation. Further testing may persuade us to reject a previously held theory, or

to stimulate the development of a better theory that explains both the old facts of the old theory, and the new facts gathered (Atkinson, 1965).

According to Bigge (1982), a new theory of learning is not translated into educational practice until 25 years or more have elapsed. Then, as a new theory eventually comes to affect educational policy and procedures, it usually does not replace its predecessors; it merely competes with them. Teachers may, therefore, have adopted conflicting features of separate instructional modes which are basically contradictory in nature. These contradictory instructional modes have produced teaching materials which may not be matched to the individual student's preferred learning style.

Learning style research shows that students can identify their own learning styles (Farr, 1971; Merritt, 1984; Marshall, 1985), and that when exposed to a teaching style which matches their learning style, test scores are higher and attitude and efficiency are improved (Tallmadge, 1969; Hodges, 1985). Further research is needed in this area (matching teaching styles to learning styles) for differing age levels, subject matter areas, and learning style instruments (Rodriguez, 1985; Curry, 1987).

If a learner's preferred learning style were known and considered, teachers would have a basis for instructional decisions which would lead to more efficient results in the classroom. These instructional decisions would not only be a significant factor in how well students master basic concepts, but would also affect the kinds of attitudes developed (Onyejiaku, 1982; Endsley, 1983).

Research on the development of attitudes indicates that student attitudes towards math are largely shaped during 4th to 8th grades (Dutton, 1956). Development of positive attitudes is central in guiding a child's mathematical development.

Attitudes have been described as having three components (Triandis, 1971; Good, 1983). These components are the cognitive component (i.e., the idea which is used in thinking), the affective component (i.e., the emotion which charges the idea), and a behavioral component (i.e., the action on the idea).

Attitudes, part of the complex factors of learning, contribute to the future perception of learning, and are functions of the total perceptual field of the individual. Altering a student's probability of success in academic achievement is only effective if attaining that success is important to him (Burgoon, 1981). Attitudes involving a desire for success and a belief in possible success are therefore of extreme importance in obtaining maximum growth in the academic achievement for each child.

To change an attitude that may have evolved primarily from affective sources may require methods different from those needed to change an attitude based on cognitive thoughts. An attack on the affective basis of the attitude may be needed (Zajonc, 1982).

Recent educational research indicates an attempt to define the best way to attack the affective basis. Many of these attempts include varying the instructional modes. Effects of these varied modes and the resulting changes in both academic achievement and attitudes have been studied (Powell, 1978; Dunn, 1978; Evertson, 1981; Beady, 1981; Hulton, 1978; Creswell, 1980; Slavin, 1977; Korth, 1982; Clasen, 1983; Jenkins, 1981; Wingo, 1980; Schenker, 1981; Morgan, 1981; Deloach, 1983; Rodriguez, 1985; Harmon, 1984; Endsley, 1983; Griffin, 1984; Roach, 1979, Virostko, 1983; Olsen, 1983; Spires, 1983; Calvano, 1985; Hodges, 1985; Simmons, 1986). The purpose of this recent research was to describe and understand educational processes and outcomes, either using concepts and measurement techniques, or by trying to refine the concepts and instructional styles used by the teacher.

The results of this current research concerning the varying of instructional modes in the classroom show inconsistent findings in regards to the relationship between attitude and academic achievement. These inconsistent findings have prompted suggestions for further research. Korth (1982) suggests the exploration of activity settings other than the traditional question/answer with teacher elaboration and seatwork. Creswell (1980) questions the effects of learner characteristics on the inconsistent results of programmed instruction studies. Research suggests studies concerning peer tutoring during team practice in math classes where the peer tutoring is thought to perhaps increase the level of achievement of both students involved (Hulten, 1978). Both Burgoon (1981) and Zajonc (1982) suggest the need to research attitudes and attitude changes. Research suggested by Evertson (1981) involves the relationship between variation in student entering ability, attitudes, and achievement.

The recommendations for further research are all a narrowing of the focus of studies to specific instructional modes/materials and their effects on academic achievement and attitudes. The findings are a result of treatments involving students who are taught according to a specific learning style and then measuring the change of academic achievement and attitude. These treatments have not involved pre-matching the students with their preferred learning styles, then using teaching materials for these styles, and finally measuring any change of academic achievement and attitude. The research which does not involve the matching of preferred learning styles to teaching materials indicates inconsistent findings and, therefore, a need for further investigation in this area (Korth, 1982; Creswell, 1980; Hulten, 1978; Burgoon, 1981; Zajonc, 1982; Evertson, 1981).

Research which has involved pre-matching of learning styles and then using teaching materials for these styles has indicated an increase in academic achievement and a growth in positive attitudes (Dunn, 1978; Hodges, 1985). Other research has indicated a need to study further the effects of matching learning styles and teaching materials to specific content areas (Tallmadge, 1969; Dunn, 1978; Farr, 1971; Olsen, 1983; Wingo, 1980; Harmon, 1984; Griffin, 1984; Simmons, 1986).

One of the content areas needing further research is that of mathematics (Olsen, 1983; Wingo, 1980; Harmon, 1984; Griffin, 1984; Simmons, 1986). The National Council of Teachers of Mathematics surveyed the opinions of many sectors of society, both lay and professional, to obtain information on current beliefs and reactions to possible mathematics curriculum changes during the 1980's (National Council of Teachers of Mathematics, 1981). The project's report, the Priorities in School Mathematics Project (PRISM), stated that two statistics topics were strongly supported for inclusion in the elementary school curriculum: collecting and organizing data, and reading and interpreting statistical information. Over 70% considered four probability and statistics topics appropriate for all secondary students: the collection and organization of data, measures of central tendency, reading and interpreting statistical information, and decision making. The National Council Of Teachers of Mathematics (1980) listed recommendations for school mathematics of the 1980's in their An Agenda for Action. Recommended action 2.1 states "The full scope of what is basic should contain at least the ten basic skill areas identified by the National Council of Supervisors of Mathematics' 'Position Paper on Basic Skills.'" One of the areas listed is "... reading, interpreting, and constructing tables, charts, and graphs". Recommended action 2.3 states that "Changes in the priorities and emphases in the instructional program should be made in order to reflect the expanded concept of basic skills."

Activities in which there should be increased emphasis include "...locating and processing quantitative information, collecting data, organizing and presenting data, interpreting data, drawing inferences and predicting from data,...".

The purpose of this study was to investigate the relationship of matching preferred learning styles to teaching materials and the resulting effects on seventh grade mathematical academic achievement and attitude in the area of graphs and statistics. Studies such as these may enable research to build a knowledge base about the effects between specific instructional materials and academic achievement and attitude that goes beyond the findings to date.

General Questions to be Answered

Answers to five main questions were sought in this study. They were:

1. Are the effects of matching teaching materials to preferred learner styles and teaching to those styles the same for males as for females during a two-week unit on graphs and statistics?
2. Are the effects of matching teaching materials to preferred learner styles and teaching to those styles the same for high, middle, and low socio-economic groups during a two-week unit on graphs and statistics?
3. Are pupils' attitudes toward mathematics affected as a result of matching teaching materials to preferred learner styles and teaching to those styles during a two-week unit on graphs and statistics?
4. Are pupils' mathematical academic achievement scores affected as a result of matching teaching materials to preferred learner styles and teaching to those styles during a two-week unit on graphs and statistics?

5. Are pupil mathematical attitudes related to (dependent upon) matching teaching materials to preferred learner styles and teaching to those styles during a two-week unit on graphs and statistics?

General Procedures

A copy of the proposed study was presented to the appropriate administrative personnel of the Bozeman Public Schools. Upon the approval of the proposal, a meeting was scheduled with the principal of the Bozeman Junior High School and the teachers involved in the study. The study was explained to the principal and teachers and their support and cooperation gained in gathering the necessary data. It was explained, at this meeting, that in order to gather objective data, the nationally normed Metropolitan Achievement Test, 5th Edition (1978), Mathematics Instructional Test (Graphs and Statistics) would be used to measure academic achievement. Further, it was explained that the Aiken-Dreger Math Attitude Scale (Appendix A) would be used to measure any change in attitudes towards mathematics.

The Pilot Study for the treatment groups was completed during a two week time period of the 1987-1988 academic year. The purpose of the Pilot Study was to finalize the procedure and develop the materials necessary for the reliability and validity of the experimental study the following year.

Students in the Pilot and Investigative Studies were divided into the treatment groups based on their learning style preferences as determined by the Gregorc Style Delineator (Gregorc, 1982). The Gregorc Style Delineator has been shown to have internal consistency reliability of 0.89 to .93 for the four scales , a test-retest reliability range from 0.85 to 0.88, predictive validity r range from 0.55 to 0.76, and a content validity of 89%.

The Pilot Study included four seventh grade mathematics classes. Three classes were divided into treatment groups and one class was used as a control group. All Pilot Study classes were taught by the researcher.

The Investigative Study was completed during the 1988-1989 academic year. Eleven seventh grade mathematics classes involving three teachers (not involving the researcher) involved 239 students. Inservice was provided for the teachers involved in the study to allow proper usage of techniques and teaching materials throughout the study. Eight classes were divided into treatment groups while three classes were used as control groups. This study involved the same treatment techniques and materials, method of student division into treatment groups, time span, testing materials, and subject area objectives as the Pilot Study.

Treatment 1 involved teaching graphs and statistics using teaching techniques appropriate for the Concrete Sequential Learner. These included the use of workbooks or laboratory manuals; lectures accompanied with overhead transparencies, drawings, or models; demonstration teaching; hands-on materials; programmed instruction or computer-assisted instruction. Students were expected to follow step-by-step directions exactly; use various drill techniques to practice what they have learned; and give correct answers available from the text.

Treatment 2 involved teaching graphs and statistics using teaching techniques appropriate for the Abstract Sequential Learner. These included the use of instructional audio tapes; extensive textbook reading assignments; lectures. Students were expected to be able and willing to read large amounts of material; be able to conceptualize ideas and convey them either orally or in writing; be able to concentrate on an idea without being distracted by environmental activities or inner feelings.

Treatment 3 involved teaching graphs and statistics using teaching techniques appropriate for the Concrete Random Learner. These included the use of games or simulations; independent study

projects; optional reading assignments; brief mini-lectures; problem solving activities. Students were expected to be able and willing to frame hypotheses, develop alternative solutions and test them; be able to solve problems with limited information or data provided; experiment with ideas and materials through application.

Treatment 4 involved teaching graphs and statistics using teaching techniques appropriate for the Abstract Random Learner. These included the use of filmstrips with audio tapes; group discussions among students; lecture with discussion of material presented; short reading assignments which are springboards for class activities. Students were expected to be able and willing to listen to, learn from, and respond to their fellow students; be aware of color, sounds and moods in their environment; observe body language, listen for intonation and reflect upon these in connection with the message being given.

The experimental Control Group involved teaching graphs and statistics according to the teachers' "usual" methods, materials, and techniques. Students were not taught using the materials appropriate to their particular learning style. Students were expected to be able and willing to use the various teaching techniques and materials to the best of their abilities.

The researcher, using statistical analysis, investigated the effects of matching learning materials with students' preferred learning styles upon academic achievement and attitudes. The researcher also investigated effects in mathematics achievement or in attitude between the genders or among socio-economic status groups (high, medium, low).

Limitations and Delimitations

The limitations for this study.

1. The study was limited by the teachers' abilities to manage the four treatment groups simultaneously in each experimental classroom.

2. The study was limited by the accuracy of the socio-economic status groupings. Groupings were established by participation and eligibility for the National School Lunch Program, and by school counselor recommendation.

The delimitations for this study.

1. The study was limited to eleven seventh grade mathematics classes of the public school system of Bozeman, Montana.

2. The Pilot Study encompassed a two-week time span during winter, 1988, while the Experimental Study encompassed a two-week time span the following fall, 1988.

3. The study encompassed the mathematical unit on graphs and statistics, only.

Definition of Terms

The definitions of the specified terms below are taken from the Dictionary of Education, edited by C. V. Good (1973). The remaining definitions are provided by the researcher and are to be considered as operational definitions.

Achievement, academic.

For the purposes of this study, academic achievement will be indicated by the pre-test and post-test scores received on the Metropolitan Achievement Test - Mathematics Instructional Tests, Graphs and Statistics.

Attitude change.

For the purposes of this study, attitude change will be the change of attitude as measured by pre-treatment and post-treatment scores on the Aiken-Dreger Math Attitude Scale.

Domain, affective.

Area pertaining to the feelings or emotions (Good, 1973:94).

Graphs and statistics.

For the purposes of this study, graphs and statistics will be the area of mathematics concerned with ways of organizing and presenting numerical data so that interpretation and use of the data is easier. Statistics presented in the unit include tabled data, frequency, and arithmetic mean. Graphs presented in the unit include bar graphs, and pictographs. Other material presented will include probability of an independent event, probability of an independent event not occurring, and the combined probability of independent events.

Learning style.

Characteristic cognitive, affective, and physiological behaviors that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment (Keefe, 1979a: 4).

Learning Preference Types.

For the purposes of this study the learning preference types will include the Concrete Sequential Learner (CS), the Abstract Sequential Learner (AS), the Concrete Random Learner (CR), and the Abstract Random Learner (AR). Descriptions of these types of Learners are identified by the research of A. F. Gregorc and H. B. Ward (1977):

CS: .....characterized by a finely tuned ability to derive information through direct, hands-on-experience. This learner exhibits extraordinary development of his five senses.

AS: .....characterized by excellent decoding abilities in the areas of written, verbal, and image symbols. Such a learner has a wealth of conceptual "pictures" in his mind against which he matches what he reads, hears, or sees in graphic and pictorial form. He has and likes to use reading skills, listening skills, and visual translation abilities. A symbol or picture is worth a thousand words to this person .

CR: .....characterized by an experimental attitude and accompanying behavior. Such learners get the gist of ideas quickly and demonstrate the uncanny ability to make intuitive leaps in exploring unstructured problem-solving experiences. Occasionally, however, they also have insights and make leaps in structured situations. They are then chided for not showing their steps or for jumping to conclusions.

AR: .....distinguishable by his attention to human behavior and an extraordinary ability to sense and interpret 'vibrations.' He is attuned to nuances of atmosphere and mood. This type of learner associates the medium with the message. He ties a speaker's manner, delivery, and personality to the message being conveyed. In doing so, he evaluates a learning experience as a whole.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Review of Literature

In the review of literature, research studies are chronologically summarized for each of two general areas. These areas are: the studies relating to learning style theory, and the studies relating to attitude theory. Interlaced in these two areas are the relationships between the area and mathematical academic achievement and the area and differences due to gender. The literature review includes general procedures, population descriptions, and the results of the studies with special emphasis given to the results in the mathematical area and middle school-junior high school age student population.

Studies Related to Learning Theory

A study done in 1966 (Belcastro) investigated the relative effectiveness of two experimental methods in the teaching of algebra. This study involved eighth grade students within a thirty-mile radius of Pittsburgh, Pennsylvania. The students in this study had not had any instruction in algebra prior to the study, and were involved in the three day experiment for one hour each day. A pre-post test was used to determine effects of the treatments. The two treatments for this study involved the teaching methods of inductive programming and deductive programming. The results of the study found a significant

difference between the two methods of programming algebra. A significant difference was also found between the two modes of programming algebra. The verbal mode of programming resulted in greater average retention than the non-verbal mode of programming materials.

The effect of modified programmed lectures and mathematical games on the achievement and attitude of ninth grade low achievers in mathematics was studied in 1968 (Jones). This study involved students ranging from fifteen to seventeen years of age and were equally distributed as "male or female, Negro or Caucasian". The objective of the study was to enable the student to progress according to programmed teaching materials. The material was presented verbally by the teacher to the student, and the games were introduced as the "practical" application of learning mathematics. Pre and post achievement and attitude tests were administered and the results analyzed. The results indicated a significant improvement of grade placement scores. Analysis of the data indicated that the underachiever had greater variability in performance on both pretest and posttest than did the slow learner. The analysis of the attitude data indicated acceptance and approval of the treatment. This supported the investigators' belief that attitude is an extremely important part of the learning process.

Niedermeyer (1969) investigated the learning and varying sequences of ninth grade mathematics materials. Subjects of this study were ninth grade students of a suburban junior high school in the Los Angeles area. They were randomly assigned to logical, scrambled or reverse order sequence conditions groups and a control group. Results of the study revealed that none of the three sequence groups differed significantly from each other on posttest performance.

The same year, 1969, Tallmadge did a study concerning relationships among inductive and deductive learning styles, instructional methods, and the nature of learning experiences.

This study involved two separate subject matter areas which represent two distinctly different learning situations. Two separate courses were developed for each subject matter area; one course reflected an inductive instructional approach and the other a deductive method. Each of the four courses was administered to 55-60 Navy enlisted men. Measures of aptitude, interest, and personality were obtained on each subject. The results of the study show significant interaction among instructional methods, learner characteristics, and subject matters. This finding, according to the researcher, strongly supported the existence of learning styles.

In October of 1970, Lach reported a study on the use of programmed workbooks to provide for partially individualized mathematics instruction in the junior high. The subjects for this study were two seventh grade mathematics classes. One class was the experimental group while the other class served as the control group. The treatment consisted of a short discussion, checking and explanation of assigned problems, presentation of new topics, and individual work in the programmed workbooks. Remedial help for students was provided during the individual work period. Matched pairs were used in the comparison to eliminate the effect of gender differences. Pre and post achievement and attitude tests were administered to determine the results. Analysis revealed no significant difference between the experimental group and the control group. The researcher, however, noted that while the differences in achievement were not significantly higher for the experimental group in every comparison, the difference was never in favor of the control group. The indication from the subject rating seemed to be that the experimental method had a "very positive effect on students' attitudes toward, and interest in, mathematics."

In 1971 a dissertation was accepted that reported the individual differences in learning, and the self-predicting of effective learning styles (Farr). College students were used as

subjects and were tested to determine the accuracy of predicting the style in which they would learn more successfully. Results obtained confirmed at beyond the .01 significance level, that for the two kinds of material employed (foreign vocabulary and comprehension/retention of narrative prose) individuals were able to predict successfully the style in which they would demonstrate superior learning performance. It was also found that the most desirable condition appears to be that in which learning and testing are both in one's preferred style.

Another dissertation in 1976 (Threadgill) reported the relationship of two cognitive styles and two methods of instruction in mathematical concept attainment. The subjects of this study were seventh grade math students. The cognitive styles in the experimental treatments were analytic cognitive style and global cognitive style, while the two methods of instruction were a discovery approach and a didactic method. Results indicated a significantly better performance by analytic students than global students. There was no significant difference between the relative effects of the two instructional methods, and no significant interaction between the two styles and the two methods of instruction.

Still another dissertation during 1976 reported the effects of cognitive style on arithmetic achievement in second, fourth, and sixth grade boys and girls (Balik). The subjects were students enrolled in a suburban school district in Westchester County. Four types of cognitive style (descriptive analytic part-whole, descriptive analytic global, relational-contextual, and inferential-categorical) were used in the treatments. Results indicated that there were significant differences in arithmetic achievement between cognitive style groups. No significant gender differences in arithmetic ability were found, and the effect of cognitive style operated independently of the gender of the subject. The researcher concluded that cognitive style influenced achievement in arithmetic.

Individual differences in cognitive styles (and the guidance variable in instruction) were studied by Thornell in 1977. Fourth grade students from a middle class school in Central Texas were randomly assigned to groups consisting of two forms of instruction (intermediate guidance vs. maximal guidance) involving two cognitive styles (global vs. analytic). The resulting four treatment groups were then tested for achievement of mathematical symmetry. The results indicated no significant differences between the two instructional treatments for subjects with the same cognitive style. Comparison of subjects with dissimilar cognitive styles indicated superior performance by analytic subjects regardless of the form of instruction used.

Dunn, Dunn, and Price (1978) reported the effects of matching learning style of the student to the teaching materials and methods used. The Learning Style Inventory, developed by the authors, was suggested to be used to identify the individual learning style. Environmental, emotional, sociological and physical elements were all considered to determine the individual learning style. Teaching materials and methods would then be matched to the predetermined learning style. Methods include small group techniques, contract activity packages, programmed instruction, programmed learning sequence, and instructional package. The types of classrooms described (matched to varying learning styles) include the traditional classroom, the individualized classroom, the open classroom and the alternative classroom. The authors base their discussions and suggestions on their own prior research studies involving pre-matching of learning styles to the instructional materials and methods used.

The same year, 1978, Hulten researched team competition and group practice and the effects on student achievement and attitudes. Seventh grade students in ten mathematics classes participated in a ten week experiment. Two reward systems (team competition vs. individual competition) and two practice modes (group practice vs. individual practice) determined the four

treatments which were studied for effects on mathematics achievement and attitude. Team competition students improved significantly more for both achievement and attitude than did individual competition students or the control students. Group practice students did not significantly improve achievement and attitude over individual competition students. The researcher concluded that team reward structure is "more important than group practice sessions".

In 1979 Roach studied the effects of conceptual style preference, related cognitive variables and gender on achievement in mathematics. The Conceptual Style Test, a mathematics achievement test and an intelligence test were administered to 206 boys and 212 girls (grade 6) in five urban Jamaican elementary schools. Mathematics achievement had significant positive correlations to analytic conceptual style and intelligence; girls had higher mathematics achievement than boys. Analytic conceptual style had a significant positive correlation with intelligence, but had no relation to gender.

Creswell (1980) studied the effects of individualized programmed mathematics experiments on achievement and attitudes of seventh grade students. A nonlecture teaching methods treatment was used for seventh grade students in Opelousas, Louisiana; the control group received "conventional methods" of instruction. Pre and post tests were used to determine the results which indicated no significant difference between the treatment group and the control group. A tentative conclusion of the researcher states "that Individual Programmed Experiments had no harmful effects on the treatment group".

Wingo, also in 1980, examined relationships among locus of motivation, sensory modality preference and grouping preference of learning style to minimum competency test performance. Eighth graders at a suburban middle school in Tennessee were given the Learning Style Inventory (Dunn) to measure learning style preferences. The Basic Skills Test was administered to

determine competency levels in reading and mathematics. Only grouping preference for reading was found to be significant. Learning style variables of locus of motivation, sensory modality preferences, and grouping preferences did not explain a significant proportion of variance in mathematics. Recommendations include further study and investigation of learning style of males and females at various age levels, content areas, and school classifications.

In 1981 Jenkins reported a study designed to examine the relation of achievement and instructional groups and how this relation was moderated by personality traits and learning style preferences. Subjects were 168 seventh grade mathematics students making up treatment groups consisting of conventional classes and individualized classes. Pre and post test scores were used to determine any significant difference between the two types of instruction on three growth groups (underachievement, expected achievement, and overachievement). Results indicated no significant difference in achievement levels between the treatment groups. The researcher suggested that criteria other than achievement could be justified for grouping procedures.

The same year (1981) Evertson studied the relationship between the affective behavior of the teacher and students' academic achievement and attitudes. Subjects of this study were English and mathematics teachers of nine junior high schools. Observers measured processes of instruction by the teachers; pre and post tests measured achievement and attitude change by students. Results indicated that high achievement-high attitude classes were characterized by good organization, a high proportion of time in instructional activity, and task-orientation. The researcher summarized that there was a distinct relationship between good classroom management and student learning and behavior.

Schenker, 1981, investigated the effect of student/teacher cognitive style matching on achievement and attitude in four

subject matter areas, and on self-esteem. The Cognitive Style Interest Inventory, the Gable-Roberts Attitude toward School Subject scale, and the Self-Esteem Inventory were administered to 129 seventh grade students and six teachers. Cognitive style match of student and teacher had no effect on achievement or attitude in any of the four subject areas. Specific cognitive style elements were found which were significantly different for high and low achievement, self-esteem, and attitude groups. Collective cognitive style was identified for high achievers in three subjects; however, none was identified for low achievers.

Morgan (1981) studied the relation between students' need for structure and student choice of mode of instruction in four subject areas for gifted elementary students. The Learning Style Questionnaire, Test for Structure (Dunn) and the Paragraph Completion Method were administered to 100 fifth and sixth grade gifted students from four school districts in western Pennsylvania. The results contributed to the conclusion that the relation between need for structure and preferred mode of instruction cannot be predicted by the classification of the instruments. No significant differences emerged between gifted students needing much structure and gifted students needing little structure when given a choice of mode of instruction for high and low cognitive learning tasks.

Onyejiaku (1982) studied the relationship among cognitive styles, instructional strategies, and academic performance of 80 subjects (age from 13 to 15 years) chosen from two schools in Ibadan, Nigeria. The subjects were divided into four groups of ten each: most analytic boys, most analytic girls, most nonanalytic boys, and most nonanalytic girls. The two methods of discovery and expository teaching, along with the two cognitive styles (analytic vs. nonanalytic) determined the treatment groups. Posttest scores were analyzed to determine the effects of the treatments on retention and transfer of mathematics tasks. Significant main effects of cognitive style were found. Analytic

boys in the expository group scored significantly higher than nonanalytic students. No significant main effects of teaching methods were found. No significant difference was found for girls in respect to cognitive styles or teaching methods.

Benbow (1983) studied the gender differences in mathematical reasoning ability. The subjects were 40,000 selected seventh grade students from the Middle Atlantic region of the United States that took the College Board Scholastic Aptitude Test as part of the Johns Hopkins regional talent search in 1980, 1981, 1982. A separate nationwide talent search was conducted in which any student under age 13 who was willing to take the test was eligible. The results of the analysis of the scores indicated that by age 13 there is a "large" difference in mathematical reasoning ability between the genders, and that it is especially pronounced at the high end of the distribution: "Among students scoring greater than or equal to 700 on the test, boys outnumbered girls 13 to 1." Reasons for this gender difference were not suggested.

Endsley, in 1983, investigated the relationships between cognitive preference, gender, and attitude on achievement scores in a first year algebra course. A group of 9th grade students in the Cherry Creek School District in Englewood, Colorado were given the Cognitive Preference Test: Mathematics (Revised) along with The E and V Scales of Aiken's Attitude Questionnaire. No significant differences were found in achievement between genders or in achievement when a student's gender and attitude were interacted.

Also in 1983 was an investigation of the relationship of learning modalities to mathematical achievement in sixth grade students (Deloach). Randomly selected sixth graders (n=126) attending seven elementary schools within one school district located in a southeastern metropolitan area were administered the Comprehensive Tests of Basic Skills, teacher ratings, and the

Swassing-Barbe Modality Index. No statistically significant difference between high and low mathematics achievement levels and auditory learners was found.

Virostko (1983) analyzed the relationships among academic achievement in mathematics and reading, assigned instructional schedules, and the learning style time preferences of third, fifth, and sixth grade students. The Learning Style Inventory (Dunn) was utilized to establish the profile of individual preferences. The investigation demonstrated that class instructional schedules coordinated with the individual time preferences were the most significant factors responsible for increasing achievement test scores in both mathematics and reading.

Another dissertation in 1983 (Olsen) investigated the differences in learning modality as they relate to academic achievement of seventh grade students. The Swassing-Barbe Modality Index, Stanford Achievement Test, and Otis-Lennon School Ability Test were administered to 188 seventh grade students from two junior high schools in a suburban community northwest of Chicago. Learning modality raw score was significantly related to the 14 achievement variables for all subjects. Modality raw score appeared to be more predictive of achievement for above average IQ males. Olsen suggested a need for further research into learning modality's relationship to achievement at the junior high level, stating that "It may be necessary to analyze modality strengths and weaknesses more critically and develop educational programs accordingly".

Spires, also in 1983, studied the effect of teacher in-service about learning styles on students' mathematics and reading achievement. The Learning Style Inventory (Dunn) was administered to students in kindergarten through sixth grade. Teachers used the skills and techniques learned in the year long in-service activities to accommodate the students' learning styles. Findings of the study included significantly more achievement of three subtests: word attack, reading

comprehension, and mathematics concepts and application. Significantly higher results on subtests requiring conceptual skills in four out of seven grade levels were also found.

In 1984 Griffin analyzed the degree to which higher level thinking skills were being attained by 225 students in the three programs of self-contained center, resource satellite, and regular classroom. Students were identified for the study when administered the Renzulli's Learning Styles Inventory, the Ross Test of Higher Cognitive Processes, the California Achievement Test, and Furth's Inventory of Piaget's Developmental Tasks. No difference was found among the programs when instructional styles and learning styles were compared. Conclusions indicated a need for emphasis on higher thinking skills in all programs and an adaptation of instructional styles to learning style preferences of students.

Harmon, 1984, correlated the correspondence between achievement in calculus and complementary cognitive style. Witkin's Group Embedded Figures Test, Gregorc's Style Delineator, and Williams' Cognitive Preference Test were administered to 68 community college students. The results of this study indicated that each of these nine cognitive styles was weakly related to achievement in calculus. The conclusion to be drawn is that "although learners have different cognitive styles, the cognitive style does not prevent nor predict achievement in calculus". Harmon suggested that preservice training for teachers and persons involved with instructional technology needs to include instruction concerning individual differences based upon cognitive styles in addition to differences based upon achievement and intelligence quotient. Conclusions stated "The educators responsibility includes providing learning experiences that facilitate learning by various cognitive styles".

Rodriguez, in 1985, also used the Gregorc Style Delineator to study the relationship between the matching of the 93 students' learning styles with the teaching strategies and content

acquisition, development of intellectual capabilities, and attitudes toward the subject in high school bilingual mathematics students in a Chicago public high school. No significant difference in the attitudes toward the subject when the teaching strategy was matched with the student's learning style was found.

Calvano studied the influence of student learning styles on the mathematics achievement of middle school students in 1985. Sixth, seventh, and eighth grade students enrolled in a public middle school (n=290) during the 1984-1985 school year were administered the Learning Style Inventory (Dunn). Significant differences were found to exist between the learning styles of high and low mathematics achievement students at the middle school level. Calvano concluded that learning styles of middle school students are identifiable for high and low mathematics achievement students at the middle school level.

Also in 1985, Hodges investigated the relationships among preferences for a formal/informal design, one element of learning style, and selected instructional environments as those variables independently and/or interactively affected students' achievement in mathematics and attitudes toward the instructional setting. Thirty-two seventh and eighth grade students in remedial mathematics classes in a New York City alternative junior high school were administered the Dunn Learning Style Inventory. No significant differences between design preferences and selected environmental conditions were found. Significant differences emerged when subjects were matched and mismatched with instructional interiors that were congruent and incongruent with their diagnosed design preferences. Indications were that the matching of individual preferences with complementary interior designs and furniture was an environmental variable capable of significantly affecting students' mathematics achievement and attitudes.

In 1986 Simmons studied the relationship among learning modalities, academic achievement, and the gender of sixth grade

students. The Swassing-Barbe Modality Index was administered to 110 sixth grade students from four elementary schools in North Little Rock, Arkansas. The Science Research Associates Assessment Survey was used to measure achievement. The study revealed that no significant relationship existed between gender and learning modalities. Simmons suggested "Further investigations with a larger sample and a different instrument to measure academic achievement are warranted".

Studies Related to Attitude Theory

A study done in 1956 (Dutton) attempted to determine general attitudes of junior high school students toward arithmetic, reasons for liking arithmetic, parts liked and disliked, and estimation of when the pupils' feelings developed. The students involved in this study were selected from one junior high school in the Los Angeles area. Ten elementary schools contributed to the student population of this school. An attitude scale, constructed by the researcher, was used to secure the data for the study. The scale had two parts: one dealing with statements of attitude toward arithmetic and the second designed to secure general information about the specific likes and dislikes of pupils. Results of the study indicated: 1) extreme dislike for arithmetic by a high number of pupils (19%), 2) 87% of pupils enjoy problems when they know how to work them well, 3) girls showed a little more dislike for arithmetic than boys, 4) reasons given by pupils for liking arithmetic were the practical aspects of the subject, 5) pupil dislike for arithmetic centered in lack of understanding, difficulty in working problems, poor achievement, and the boring aspects of arithmetic, 6) lasting attitudes toward arithmetic developed at each grade level, grades 5 and 7 were pronounced the most crucial, 7) mechanical manipulation of numbers appealed to a large group of pupils, 8) word problems were disliked by a sizable

group of students, and 9) about a third of the pupils recognized changes in attitudes during the junior high school years.

In 1961, Aiken did a study on the effect of attitudes on performance in mathematics. This study involved entering freshmen at a southeastern college who elected their mathematics for the fall semester. Subjects were administered a math attitude scale questionnaire. Inasmuch as a pilot study had indicated the possibility of gender differences in math attitudes, most of the analyses were carried out on sections of general mathematics and hypotheses were tested for males and females separately. The results of this study indicate that math attitudes are apparently related to intellective factors and achievement, but not to temperament variables. Experiences with former mathematics teachers are related to present math attitudes, but parental encouragement and math attitudes, and own remembered traumatic experiences are not related. Direct experiences in relation to mathematics were found to contribute to math attitudes.

The following year (Dutton, 1962) a study was done on the attitude change of prospective elementary school teachers toward arithmetic. The purpose of this study was twofold: 1) to devise new ways to apply an attitude scale prepared by the researcher in 1951, and 2) to search for changes in attitudes of prospective elementary school teachers toward arithmetic during the period of 1954-1962. The subjects were elementary school teachers enrolled in curriculum classes at the University of California, Los Angeles, and were restricted to women students. The subjects were administered the attitude scale and the results analyzed. Both favorable and unfavorable attitudes were expressed by most students. Students were found to have ambivalent feelings toward arithmetic, since students liked some aspects of arithmetic and disliked others. Attitudes toward arithmetic, once developed, were found to be tightly held. Efforts to redirect the negative attitudes of these subjects into constructive channels had not

been very effective. Results of this study had remained approximately the same as the study in 1954.

In 1964, Aiken researched personality correlates of attitude toward mathematics. The subjects for this study were limited to females since non-intellective factors were found to be more influential in determining the attitudes of females toward mathematics than those of males (Aiken, 1961). The Math Attitude Scale, written by the researcher, was administered to college sophomores in a psychology laboratory course at a southeastern woman's college. Results of this study indicate that women with more favorable attitudes toward mathematics tend to be more outgoing, conscientious, self-controlled, intellectually mature, and place more value on theoretical matters than those with less favorable attitudes toward mathematics. The findings suggested that attitude toward mathematics is related to a broad range of personality variables indicative of adjustment and interest.

A study on attitude toward arithmetic at the fourth and fifth grade levels was done in 1969 (Cox; Capps). This study was based on the study done by Dutton (1962) that concluded that grades 4-8 appear to be crucial years in developing a favorable arithmetic attitude. The students involved in this study were fourth and fifth grade students randomly chosen to participate from a small mid-western city. A questionnaire, designed by the investigator, was administered by the classroom teachers. The results of the study revealed a significant difference occurring between the attitude measures of fourth grade boys and girls, with the girls having the more favorable attitude. No significant difference occurred between the attitude measures of fifth grade boys and girls. It was concluded that some unknown and undetermined factors influence girls more strongly than boys in a favorable attitude toward arithmetic at or before the fourth grade level. The authors

of this study suggested further research to determine the exact relationship between these factors and the significant difference that occurred.

Aiken, in 1972, again reported upon research on attitudes toward mathematics. This review indicated that attitudes toward mathematics vary according to education, ability, gender, and grades received in mathematics classes. Attitudes towards mathematics are related to students' perceptions of the attitudes and abilities of their teachers and parents. Aiken concluded that "Since the relationships vary with educational level and sex, a whole complex of variables needs to be taken into account if more comprehensive statements about the origins, effects, and modifications of attitudes toward mathematics are to be made."

In 1982 Ben-Haim studied existing differences in spatial visualization abilities and in attitudes toward mathematics of fifth through eighth grade students by gender and grade prior to an instructional intervention. The analyses of the effects of instruction on the spatial visualization skills and attitudes toward mathematics of a sample of sixth, seventh, and eighth grade students by gender and grade was also done. Fifth through eighth grade students (n=1327) from three sites in and around Lansing, Michigan, participated in the study of existing differences. Four hundred thirty of these students participated in the effects of instruction and comparison of attitudes study. Prior to instruction, significant results were found for grade differences in spatial visualization performance, for attitudes toward mathematics; gender differences in spatial visualization performance, but no gender differences in attitudes toward mathematics. After the instruction students performed significantly higher on the spatial visualization test; however, no change in attitudes toward mathematics occurred. Boys and girls gained similarly from the instruction; students' attitudes toward mathematics and spatial visualization were similar. Grade

differences in attitudes toward spatial visualization were found, but no gender differences. Retention of effects persisted.

Cramond (1982) studied the predicting mathematics achievement of gifted adolescent females. Cognitive variables (spatial visualization and flexible thinking) were studied for 88 girls in eighth grade and 132 twelfth grade girls in the New Orleans Public School System. The Differential Aptitude Test-Space Relations, the Torrance Test of Creative Thinking-Demonstrator form, the Bem Sex Role Inventory, selected scales from the Fennema-Sherman Mathematics Attitudes Scales, and the Arithmetic Skills Test of the Comprehensive Test of Basic Skills were administered. Spatial visualization and attitude toward success were the only significant predictors of mathematics achievement at the eighth grade level. For the twelfth graders, the significant predictors were spatial visualization and students' perceptions of their counselors' attitudes toward them as learners of mathematics. The results of this study indicated that cognitive and affective variables may be related to mathematics achievement for gifted adolescent females. Cramond also stated "the responsibility of the schools to increase females' participation and achievement in mathematics is seen as critical".

In 1982 Verbeke investigated gender related differences in mathematically gifted secondary students. Ninety students in grades 8, 10, and 11, identified as being mathematically gifted from Carroll County, Maryland were administered the Space Relations Subtest of the Differential Aptitude Test, four of the Fennema-Sherman Mathematics Attitudes Scales, and a mathematics course-taking questionnaire. Results supported a positive relationship existing between course-taking and spatial visualization skills and attitude toward the usefulness of mathematics. No significant differences were found between males and females. No gender-related differences were found in many of the areas where differences have been found in previous research.

Another dissertation in 1982 (Rapoport) investigated gender differences in causal attributions for math performance. Thirty male and thirty female students at the 3rd, 5th, 7th, 9th and 11th grade levels in a predominantly white, middle-class school district were given a questionnaire to assess their expectancy of success, as well as attributions and feelings following both success and failure in math. Results show that there were no significant gender differences in expectancy of success in math before 7th grade. No significant gender differences in expectancy of success nor in attributions following 7th grade were found either. No significant gender difference in math or English achievement at any grade level was found.

Peters, 1982, studied the effectiveness of four treatments for mathematics anxiety with a population of 48 eighth grade girls. The first treatment was tutoring, the second was self-instruction training, the third treatment combined self-instruction training with study-skills training, and the fourth treatment was a control group. Differences on dependent measures before and after treatment were not great enough to be statistically significant.

In 1983 Samuels studied mathematics achievement and attitude in grades six through eight in Lebanon, Oregon. The Aiken's Mathematics Attitude Scale and the Comprehensive Test of Basic Skills were administered. Attitudes toward mathematics were positive rather than neutral and were positively correlated with achievement.

Corbo, in 1984, examined mathematics attitude and achievement in grades five through seven in a southcentral Pennsylvania school district. Six hundred students attending a small rural middle school were administered the Iowa Tests of Basic Skills and a semantic differential attitude scale developed by Anttonen. Significant differences in student attitude were found for the main effects of achievement and grade level and for the two way interaction effects of the same two variables. Findings of the study implied that gender is not a significant

factor in the development of attitude toward mathematics of the attitude-achievement relationship for students in grades 5 through 7. Attitude in general was only slightly related to achievement. The grade level of students was a significant factor in both the development of student attitudes and the strength of the attitude-achievement relationship.

Goldstein, in 1984, analyzed the structure of attitude toward mathematics among junior high school students. Fifty male and fifty female eighth grade students responded to an attitude questionnaire composed of statements from the Mathematics Attitude Inventory by Sandman and the Fennema-Sherman Mathematics Attitude Test. Factor analysis confirmed the existence of the three components of attitude (affective, behavioral, and cognitive). Neither all dimensions nor all factors were significant predictors of achievement with different components being important for boys and for girls.

Costello, also in 1984, determined the degree of relationship between ability grouping upon students' perception of their classroom social climate, and the relationship of the climate upon student academic achievement. Two hundred twelve students from an Indiana high school were administered the Classroom Environment Scale (CES) in ability grouped ninth grade mathematics and English classes. Significant statistical findings were: students in the higher ability grouped mathematics classes viewed their climate more positively on seven of nine CES subscales and seven of the nine CES subscales had a significant positive relationship with student achievement. Further research, it was suggested, is necessary to develop strategies to change the students' perception of the classroom social climate and to determine if this change in perception improves achievement.

Mott, 1984, assessed elementary students' attitudes toward their learning experience in a diagnostic prescriptive mathematics program. Instruments provided in the Pennsylvania Department of Education's Diagnostic and Prescriptive Mathematics Program

were administered to 540 students in grades five through eight. Teachers and principals in this study felt that it "is important for teachers to have an idea of their students' attitudes toward significant aspects of their learning experience."

The development of an instrument to measure mathematics attitude of elementary children was developed in 1985 (Blitch). Testings of this instrument indicated that younger students had more positive attitudes toward mathematics than older students. A significant difference in mathematics attitude was found between girls and boys.

Research in 1985 (Holleran) studied the relationship between student perceived locus of control and academic performance of sixth, seventh, and eighth grade male and female students in English and mathematics classes. Scores on a locus of control instrument were obtained from male and female middle school students enrolled in mathematics and English classes. These scores were then correlated with their teacher-assigned grades. No statistically significant relationships were found between grade point averages and locus of control classification as external or internal for students in any of these independent groups.

In 1985 Mason studied elementary school students' achievement-related cognitions, emotions, task behavior and performance. Seventy-seven fourth and fifth grade students from four middle to lower middle class urban elementary schools participated in the first year; 41 of these students were participants in the second year. Students' achievement related cognitions were generally related to each other in predictable ways. Students' cognitions and emotions did not predict their classroom task behavior, but did to some extent, predict performance. Findings suggested that students' achievement related beliefs and emotions may, therefore, influence their performance in ways that are not directly observable.

The relation between fear of success, field-dependence and math anxiety to mathematics achievement in gifted boys was studied in 1985 (Berman). Ninety-seven fifth and sixth grade boys attending a private school in New York City were administered the mathematics subtests of the Comprehensive Testing Program II, the Confidence in Learning Mathematics scale of the Fennema-Sherman Mathematics Attitudes Scales II, the Group Embedded Figures Test, and the Revised Children's Fear of Success Scale. The finding that field-dependence is a critical psychological mediator between fear of success in children and their performance in mathematics was discussed.

Hadfield, in 1986, studied cognitive style and mathematics anxiety among 481 high school students. High school mathematics students were administered the Witkin Group Embedded Figures Test. Results included one significant main effect and two significant first order interactions. Cognitive style showed a main effect with mathematics anxiety, and cognitive style also interacted with both achievement level and gender. Field dependent students tended to develop more mathematics anxiety than field independent students.

Research, also in 1986 (Smith), examined previously untested interaction effects between locus of control and the variables of gender, race, and socioeconomic status (SES). Sophomores (n=22,237) and seniors (n=21,110) utilized in this investigation were selected from the High School and Beyond (1980) data base. Locus of control was found to be a statistically significant predictor of all six dependent variables. It was concluded that locus of control has a practically significant but low level main effect in predicting sophomore reading and math achievement, senior reading and math achievement, and senior GPA. No significant first order interaction effects of practical importance between locus of control and gender, race, and SES were found, nor is there a significant second order interaction effect of practical importance between locus of control and race and SES.

CHAPTER 3

PROCEDURES, METHODS AND ANALYSES OF DATA

Procedures

The purpose of this study was to determine, for seventh grade mathematical students of the Bozeman Public Schools, the effects of matching teaching materials with students' preferred learning styles upon mathematical academic achievement and attitudes during a two-week mathematical unit on graphs and statistics. This investigation also included a study of any change of mathematical achievement or change in mathematical attitude between the genders or among socio-economic status groups.

This chapter will begin with a description of the population and sampling procedure. The experimental treatments are defined and irrelevant and contaminating variable controls are discussed. The methods of collecting data are then explained and the accuracy of these methods described. The next section of the chapter will discuss the method of organizing data. Next, the statistical hypotheses are listed. The analysis of data is then explained along with the precautions taken to insure accuracy in the collection, analysis and presentation of the data.

Population Description and Sampling Procedure

The population of the Investigative Study consisted of the students in all the seventh grade mathematics classes at the

Bozeman Public Schools during the 1988-1989 academic year. The seventh grade mathematics classes consisted of eleven classes (two teachers with four classes each and one teacher with three classes) of approximately 25 students each. Students had been randomly selected by computer for these classes. The eleven classes were randomly assigned as follows: 3 classes were the control classes, 8 classes were the experimental treatment classes. Each of the teachers was assigned a randomly chosen control class while the remainder constituted the experimental treatment classes. Each of the 8 experimental treatment classes were divided into the 4 learning style treatment sub-groups according to the results of the Gregorc Style Delineator (Concrete Sequential, Concrete Random, Abstract Sequential, and Abstract Random). Each teacher, therefore, managed these 4 treatment groups simultaneously in each experimental treatment class. Because a pairing of the pre- and post-test Metropolitan Achievement Mathematical Instructional Tests (graphs and statistics) scores and a pairing of the pre- and post- Aiken-Dreger Math Attitude Scale scores were necessary to obtain difference scores, only students with complete test scores on both sets of pre- and post-tests were used in the analysis of the data.

The students in this study either lived in the city of Bozeman or in the immediate rural vicinity. Bozeman has a population of approximately 30,000 and is located in Gallatin County, Montana. The economy of Bozeman is mainly agricultural, but does include small businesses engaged in lumbering, electronics and other small manufacturing operations. Montana State University, the largest employer in the city of Bozeman and in Gallatin County, is also located in Bozeman and has a student population of approximately 10,000.

Treatment Definitions

Treatment 1: Concrete Sequential group.

The teaching materials designed for this group involved workbooks and lab manuals, lectures accompanied by overhead transparencies, drawings or models, hands-on materials and equipment, and programed or computer-assisted instruction.

Treatment 2: Abstract Sequential group.

The teaching materials designed for this group involved extensive reading, lectures, instructional audio-tapes.

Treatment 3: Concrete Random group.

The teaching materials designed for this group involved games, simulations, independent study projects, optional reading assignments, problem-solving activities, and brief mini-lectures that set the stage for exploration.

Treatment 4: Abstract Random group.

The teaching materials designed for this group involved short reading assignments followed by class activities, group discussions, lectures followed by discussion, group or team work, filmstrips with audio tapes, and assignments that permitted reflection or "soaking" time.

Control group.

The teaching materials for this group involved the traditional classroom set-up. Each teacher conducted the class using his/her usual methods, materials, and techniques.

Variable Controls

Inservice was given for the three teachers involved to provide consistency in the administration of each treatment. Inservice was given to provide effective and efficient usage of the materials designed for each treatment.

The Pilot Study in 1987-1988 assured the completion of all needed teaching materials for each of the treatments. The Pilot Study statistical analyses (Appendix C) helped provide validity for the study. No significant difference was found for any of the Null Hypotheses except for the Pilot Study Control Group main effect of SES Groups for the dependent variable of mathematical academic achievement. A significance level of $p \leq .000$, though, is suspect. Cell sizes for the low, medium, and high SES groups were n=1, n=1, and n=20 respectively. Small cell sizes may dramatically skew the results (Ferguson,1981).

The Pilot Study post hoc Scheffe' comparison test for determining the location of the significant differences among the 3 socio-economic status (SES) groups indicated two pairs of groups of socio-economic status groups significantly different at the .05 level. The pairs include: 1) the "high" (n=7) and "low" (n=1) groups and 2) the "medium" (n=1) and "low" (n=1) groups. It must be reemphasized, however, that since the sample size in each of these cells is so low, results are skewed beyond appropriate correct interpretation.

Control groups allowed comparisons for the treatment groups. These comparisons also helped control any contaminating and irrelevant variables. Since each teacher was randomly assigned 1 class as his/her Control class, teacher variable was decreased. The three Control classes, then, determined the Control Group for the study.

Double checked hand scoring of the Gregorc Style Delineator and computer scoring of the Aiken-Dreger Math Attitude Scale, and Metropolitan Achievement Instructional Test (Graphs and Statistics) helped control any contaminating and irrelevant variables.

Method of Collecting Data

In this study, the Metropolitan Achievement Test (MAT), 5th Edition (1978), Mathematics Instructional Test (graphs and statistics) was used to gather the data for change in mathematical academic achievement. The test was considered to have "content validity" due to the extensive development of content specifications, item writing, tryout, and revision of test items. Test items matched 100% with the Bozeman Junior High School 7th grade math scope and sequence (graphs and statistics) curriculum which further supported content validity of the MAT for use in this study. Extensive norms were provided for this edition of the MAT, including percentile ranks and stanines for both fall and spring administrations for pupils, buildings, and systems; scaled scores comparable across forms and levels (though not across content areas); grade equivalents; and fall and spring item p values. As with earlier editions of the MAT, norms were based on separate, matched samples tested in fall and spring. Normative data was also reported for each objective on the instructional tests, and for item clusters spanning related objectives on the survey tests. KR-20 reliabilities and standard errors of measurement were nearly all over .80, with many over .90. The KR-20 reliability for the Graphs and Statistics subtest was .81. The same form was used for both the pre- and post- test scores. The pre and post tests were given immediately before and after the two-week unit on graphs and statistics. Scoring was done by computer.

The Gregorc Style Delineator was used to determine the preferred learning style for each student. Students in the treatment classrooms were separated into the 4 learning styles according to the results of the Delineator. Reliability was found for internal consistency and stability. The internal consistency as measured by a standardized alpha coefficient was found to range from 0.89 to .93 for the four scales of the Delineator. The stability, repeatability, reliability test-retest correlation coefficients ranged from 0.85 to 0.88 and were all significant at the $P<0.001$ level. Predictive validity was found for two separate tests. Tests consisted of subjects who took the Gregorc Style Delineator and then rated themselves on a randomly ordered list of characteristics attributed to individuals classified by the Delineator. The Delineator scores and the attribute scores were correlated. The first test r ranged from 0.55 to 0.68 while for the second test r ranged from 0.60 to 0.76. Validity was also found for content. Subjects were administered the Gregorc Style Delineator and then given a list of characteristics attributed to the classification yielded by the Delineator. Each subject then rated on a scale of 1 to 5 (1=strongly agree, 5=strongly disagree) the degree to which he or she agreed with the attributes. 89% (424/475) "Agreed" or "Strongly Agreed" that the characteristics theoretically attributed to the classifications in which they found themselves according to the Gregorc Style Delineator represented them well. The Gregorc Style Delineator consists of 10 sets of four words each. The words were to be ranked in order of the best and "most powerful descriptor of your self". The word in each set best fitting "your self" was given a rank of 4, the next best word was given a rank of 3, and so on. The Delineator word rankings were hand scored.

The Aiken-Dreger Math Attitude Scale was used to determine any change in mathematical attitude. 20 statements required respondents to indicate on a five-point Likert-type scale their agreement/disagreement with statements that reflect a positive

or negative bias toward mathematics. Paragraphs describing attitude toward mathematics written by 310 college students were reduced to scaled items according to Likert's procedure to constitute the basis for the Math Attitude Scale. The final scale consisted of 10 items connoting negative attitudes (fear) and 10 connoting positive (enjoyment) (Aiken, 1961; Adwere-Boamah, et al., 1986). Investigation of test-retest reliability provided r=.94. (Aiken, 1961). Reliability coefficients for the items representing Enjoyment and Fear were .93 and .87, respectively (Adwere-Boamah, et al., 1986). A test of independence between the scores on the Attitude Scale and scores on 4 items designed to measure attitudes toward academic subjects in general tested content validity. Results of this test of independence suggested that attitudes specific to mathematics were being measured (x^2=.80, df=1) (Aiken, 1961). Since the content of the test measured what was desired for this study, content validity was established. In scoring the opinionnaire, the five points on each scale are weighted with integers (such as from one to five) in the direction dislike-like mathematics, and the scores for each item were then added (Aiken, 1964). The same form was used for both pre- and post-test scores. The pre and post Scales were given immediately before and after the two-week unit on graphs and statistics. The test was computer scored.

Method of Organizing Data

The data was organized in such a way as to classify the students by mathematical academic achievement and mathematical attitude. Further classifications were made within each treatment on the basis of gender and of socio-economic status groups.

The basis for determining the mathematical academic achievement groups was the individual performance on the difference scores on the pre- and post- Metropolitan Achievement

Test results. The achievement groups were classified as low, medium, and high. The mean and standard deviation for the difference scores were used to determine these groups. The low group was determined by those students whose scores were 1/2 standard deviation or more below the mean. The high group was determined by those students whose scores were 1/2 standard deviation or more above the mean. The remaining students determined the medium group.

The basis for determining the mathematical attitude change groups was the individual performance on the difference scores on the pre- and post- Aiken-Dreger Math Attitude Scale. In scoring the opinionnaire for the difference scores, the five points (Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree) on each scale were weighted with integers from five to one, respectively. The summation of the selected responses by each student determined the Attitude Scale Score. The Difference Score for each student was the result of the difference between the Pre and Post-Test Math Attitude Scale. The mathematical attitude change groups were classified as low change, medium change, and high change. The mean and standard deviation for the difference scores were used to determine these groups. The low change group was defined as being 1/2 standard deviation or more below the mean, the high change group was defined as being 1/2 standard deviation or more above the mean, and the remaining students constituted the medium change group.

The nominal and ordinal data for the Aiken-Dreger Math Attitude Scale was tested using the Chi-square independence test. The Chi-square Test of Independence (utilizing the expected and observed frequencies for the variables) determined the significant dependence between the 4 Learning Style Treatment Groups and the 5 Likert-style response categories for each Aiken-Dreger Attitude Scale statement (Ferguson, 1981). Since a contingency table with 20 cells (4 treatments by 5 Likert-style answers) would have been difficult to interpret correctly, a "collapsed"

contingency table was used for each of the Attitude test questions. The collapsed table related the two Concrete learning styles (Sequential and Random) and the two Abstract learning styles (Sequential and Random) to the 5 Likert-style answers.

The classification of socio-economic status groups was determined by the participation and eligibility in the National School Lunch Program. Children who qualified in the "Free Lunch" category were grouped in the "low" socio-economic status group; children who qualified in the "Reduced Lunch" category were grouped in the "medium" socio-economic status group; children who did not qualify or who did not apply for the Program were grouped in the "high" socio-economic status group. Students who had not applied for the Program but who, according to the 7th grade school counselor, should have been in the "low" or "medium" socio-economic status groups were also placed in those groups.

The classification of gender needs no further explanation.

Statistical Hypotheses Tested

This study tested the following null hypotheses.

1. There are no significant interactions between gender and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

    a) There are no significant differences between males and females for the dependent variable of mathematical academic achievement.

    b) There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

2. There are no significant interactions between gender and the 4 learning style treatment groups for the dependent variable of mathematical attitude.

   a) There are no significant differences between males and females for the dependent variable of mathematical attitude.

   b) There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical attitude.

3. There are no significant interactions between the 3 socio-economic groups and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

   a) There are no significant differences between the 3 socio-economic groups for the dependent variable of mathematical academic achievement.

   b) There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

4. There are no significant interactions between the 3 socio-economic groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude.

   a) There are no significant differences between the 3 socio-economic groups for the dependent variable of mathematical attitude.

   b) There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical attitude.

5. There are no significant interactions between the 3 mathematical academic achievement groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude.

   a) There are no significant differences between the 3 mathematical academic achievement groups for the dependent variable of mathematical attitude.

   b) There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical attitude.

6. There are no significant interactions between the 3 mathematical attitude groups and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

   a) There are no significant differences between the 3 mathematical attitude groups for the dependent variable of mathematical academic achievement.

   b) There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

7. The 3 mathematical attitude change groups are independent of the 4 learning style treatment groups.

8. The Mathematical Attitude Scale responses are independent of the 4 learning style treatment groups.

If differences were found between independent variables, a Scheffe' post hoc analysis was to have been performed where appropriate (Ferguson, 1981).

Analysis of Data

The analysis of the data was completed in a similar manner for each treatment. For the analysis, only the students with complete test scores for both the pre- and post test on both the MAT and the

Aiken-Dreger Math Attitude Scale were used. The null hypotheses was tested at the 0.05 level of significance using the F statistic. The 0.05 level of significance means that there are five chances in one hundred of rejecting the null hypotheses when it is true. The consequence of a Type I error (rejecting a true null) is the possibility of attributing greater change to mathematical academic achievement and/or attitude due to the Treatment(s) then is actually true. The consequence of a Type II error (retaining a false null) is the possibility of not utilizing a teaching method treatment that could benefit students (Ferguson, 1981). Since the consequence of the Type II error was of more importance to this study, the level of significance was set to 0.05, rather than to 0.01. This increased the chance of a Type I error, but reduced the chance of a Type II error (Ferguson, 1981).

Precautions Taken for Accuracy

Scoring of the Gregorc Style Delineator was duplicated and results compared to ensure maximum accuracy of data analysis. Scoring of the Aiken-Dreger Math Attitude Scale, the Metropolitan Achievement Test (5th Edition, 1978, Mathematics Instructional Test - Graphs and Statistics), the computations for the means and standard deviations, Chi-squares, and the Analysis of Variance was done by the computer facilities at Montana State University. The computer was used to eliminate mathematical errors and to expedite the analyses.

CHAPTER 4

FINDINGS, INTERPRETATIONS AND DISCUSSION

Findings and Interpretations

The general areas of concern of this study were:

1) Is there a relationship between matching teaching materials with students' preferred learning styles upon mathematical academic achievement and attitudes during a two-week mathematical unit on graphs and statistics?

2) Is there any change of mathematical achievement or change in mathematics attitude between the genders or among socio-economic status groups during a two-week mathematical unit on graphs and statistics?

These areas of concern led to the formulation of six questions to be answered by the investigation. To answer these questions three types of statistical analyses were performed: Two-way Analysis of Variance, Chi-Square Test of Independence, and the post-hoc Scheffe' Analysis where appropriate.

Each statistical analysis was performed separately for the control groups and for the experimental groups of the Investigative Study. Results were compared and used to further the interpretation of the data. Table 1 lists the total number of students, total number of males and females, the number of students in each socio-economic status (SES) group, the number of students in each mathematical attitude change group (ATTGRPS), the number of students in each academic achievement group

(ACHGRPS), and the number of students in each learning style treatment group (LS) for the Experimental Group and for the Control Group.

Table 1. Number of Students in Each Group.

Number Students	INVESTIGATIVE STUDY Experimental Group	Control Group
total	180	59
males	87	22
females	93	37
Low SES	34	10
Middle SES	19	5
High SES	127	44
Low ATTGRPS	41	19
Middle ATTGRPS	98	25
High ATTGRPS	41	15
Low ACHGRPS	49	15
Middle ACHGRPS	79	29
High ACHGRPS	52	15
Learning Style I	32	12
Learning Style II	23	5
Learning Style III	63	17
Learning Style IV	62	25

The different types of statistical analyses performed were used as the major sections of this chapter. Within each section the applicable general question was presented followed by the findings. This tabled data was then interpreted after each hypotheses was presented.

Two-Way Analysis of Variance

This statistical analysis involved the first general question:

1. Are the effects of matching teaching materials to preferred learner styles and teaching to those styles the same for males as for females during a two-week unit on graphs and statistics?

Null hypotheses 1 and 2 were presented to answer this question. The results are given in Tables 2-9.

Tables 2-3 give the Table of Means for determining significant interaction and significant differences for main effects between gender and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement. D is the mean of pre-post MAT differences while () is the number of students in each category.

Table 2. Control Group. Table of Means. Hypotheses 1.1a.1b.

	Learning Style Treatment Groups			
Gender	I	II	III	IV
male D	0.40 (5)	2.33 (3)	2.29 (7)	0.29 (7)
female D	3.57 (7)	3.00 (2)	2.20 (10)	1.50 (18)

Table 3. Experimental Group. Table of Means. Hypotheses 1,1a,1b.

	Learning Style Treatment Groups			
Gender	I	II	III	IV
male D	1.67 (18)	1.11 (9)	1.81 (32)	2.07 (28)
female D	1.43 (14)	2.71 (14)	0.84 (31)	1.65 (34)

Tables 4-5 report the Analysis of Variance results for determining significant interaction and significant differences for main effects between gender and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

Table 4. Control Group. ANOVA Results. Hypotheses 1,1a,1b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	25.869	3	8.623	1.276	0.292
columns (gender)	18.847	1	18.847	2.790	0.101
RxC	18.484	3	6.161	0.912	0.442
within	344.538	51	6.756		
total	400.949	58	6.913		

Table 5. Experimental Group. ANOVA Results. Hypotheses 1,1a,1b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	14.457	3	4.819	0.685	0.562
columns (gender)	5.022	1	5.022	0.714	0.399
RxC	27.201	3	9.067	1.289	0.280
within	1209.865	172	7.034		
total	1255.244	179	7.013		

Null Hypothesis 1:

There are no significant interactions between gender and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

The results in Tables 4 and 5 indicated no significant interactions for the Control Group nor for the Experimental Group between gender and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement. The F value of .912 for the Control Group had a significance level of .442 while the F value of 1.289 for the Experimental Group had a significance level of 0.280. Null hypotheses 1, therefore, for both the Control and Experimental Groups was retained.

Null Hypothesis 1a:

There are no significant differences between males and females for the dependent variable of mathematical academic achievement.

The results in Tables 4 and 5 indicated no significant differences between males and females for the dependent variable of mathematical academic achievement. The F value of 2.790 for the Control Group had a significance level of .101 and the F value of .714 for the Experimental Group had a significance level of .399. Null Hypothesis 1a for both the Control and Experimental Groups was, therefore, retained.

Null Hypothesis 1b:

There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

The results in Tables 4 and 5 also indicated no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical academic achievement. F value of 1.276 for the Control Group had a significance level of .292 while the F value of .685 for the Experimental Group had a significance level of .562. Null Hypothesis 1b for both the Control and Experimental Groups was retained.

Tables 6-7 report the Table of Means given for determining significant interaction and significant differences for main effects between gender and the 4 learning style treatment groups

for the dependent variable of mathematical attitude change. D is the mean of pre-post MAT differences while () is the number of students in each category.

Table 6. Control Group. Table of Means. Hypotheses 2,2a,2b.

	Learning Style Treatment Groups			
Gender	I	II	III	IV
male D	-0.60 (5)	0.33 (3)	-0.29 (7)	0.00 (7)
female D	0.00 (7)	0.00 (2)	-1.00 (10)	0.28 (18)

Table 7. Experimental Group. Table of Means. Hypotheses 2,2a,2b.

	Learning Style Treatment Groups			
Gender	I	II	III	IV
male D	1.83 (18)	1.89 (9)	1.59 (32)	2.50 (28)
female D	-0.50 (14)	0.21 (14)	0.26 (31)	0.94 (34)

Tables 8-9 give the Analysis of Variance results for determining significant interaction and significant differences for main effects between gender and the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

Table 8. Control Group. ANOVA Results. Hypotheses 2,2a,2b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	9.050	4	2.263	0.097	0.983
columns (gender)	.003	1	.003	0.000	0.991
RxC	3.670	3	1.223	0.053	0.984
within	1184.906	51	23.233		
total	1197.627	58	20.649		

Table 9. Experimental Group. ANOVA Results. Hypotheses 2,2a,2b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	29.830	3	9.943	0.212	0.888
columns (gender)	118.293	1	118.293	2.524	0.114
RxC	5.348	3	1.783	0.038	0.990
within	8061.783	172	46.871		
total	8208.950	179	45.860		

Null Hypothesis 2:

There are no significant interactions between gender and the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

The results in Tables 8 and 9 indicated no significant interaction between gender and the 4 learning style treatment groups for the dependent variable of mathematical attitude change. F value of .053 for the Control Group at a significance level of .984 and an F value of .038 for the Experimental Group at a significance level of .990 required that Null Hypothesis 2 be retained for both Control and Experimental Groups.

Null Hypothesis 2a:

There are no significant differences between males and females for the dependent variable mathematical attitude change.

The results in Tables 8 and 9 indicated no significant differences between gender for the dependent variable of mathematical attitude change. F value of .000 at a significance level of .991 for the Control Group and an F value of 2.524 at a significance level of .114 for the Experimental Group required Null Hypothesis 2a be retained for both Control and Experimental Groups.

Null Hypothesis 2b:

There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

The results in Tables 8 and 9 also indicated no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical attitude change. An F value of .097 at a significance level of .983 for the Control Group and an F value of .212 at a significance level of .888 for the Experimental Group required Null Hypothesis 2b be retained for both Groups.

Two-way Analysis of Variance also involved the second general question:

2. Are the effects of matching teaching materials to preferred learner styles and teaching to those styles the same for high, medium, and low socio-economic status groups during a two-week unit on graphs and statistics?

Null Hypotheses 3 and 4 were presented to answer this question. The results are given in Tables 10-17.

Tables 10-11 report the Table of Means for determining significant interaction and significant differences for main effects between the 3 socio-economic status groups and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement. D is the mean of pre-post MAT differences while () is the number of students in each category.

Table 10. Control Group. Table of Means. Hypotheses 3,3a,3b.

Socio-economic Status Group	Learning Style Treatment Group I	II	III	IV
low D	3.25 (4)	4.00 (1)	3.00 (1)	-0.25 (4)
medium D	0.00 (0)	0.00 (0)	0.00 (1)	2.00 (4)
high D	1.75 (8)	2.25 (4)	2.33 (15)	1.29 (17)

Table 11. Experimental Group. Table of Means. Hypotheses 3,3a,3b.

Socio-economic Status Group	Learning Style Treatment Group I	II	III	IV
low D	1.29 (7)	2.25 (4)	2.00 (14)	3.78 (9)
medium D	1.50 (2)	3.67 (3)	2.00 (4)	2.10 (10)
high D	1.65 (23)	1.75 (16)	1.07 (45)	1.37 (43)

Tables 12-13 give the Analysis of Variance results for determining significant interaction and significant differences for main effects between the 3 socio-economic status groups and

the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

Table 12. Control Group. ANOVA Results. Hypotheses 3,3a,3b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	19.136	3	6.379	0.876	0.460
columns (SES groups)	0.359	2	0.180	0.025	0.976
RxC	24.897	4	6.224	0.855	0.497
within	356.613	49	7.278		
total	400.949	58	6.913		

Table 13. Experimental Group. ANOVA Results. Hypotheses 3,3a,3b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	12.840	3	4.280	0.611	0.609
columns (SES groups)	34.141	2	17.070	2.437	0.091
RxC	31.083	6	5.180	0.740	0.619
within	1176.865	168	7.005		
total	1255.244	179	7.013		

Null Hypothesis 3:

There are no significant interactions between the 3 socio-economic status groups and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

The results in Tables 12 and 13 for the Control Group and for the Experimental Group indicated no significant interaction between the 3 socio-economic status groups and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement. The F value was .855 at a significance of .497 for the Control Group, while the F value was .740 at a significance of .619 for the Experimental Group; Null Hypothesis 3 was, therefore, retained.

Null Hypothesis 3a:

There are no significant differences between the 3 socio-economic status groups for the dependent variable of mathematical academic achievement.

The results in Tables 12 and 13 for the Control and Experimental Groups indicated no significant difference between the 3 socio-economic status groups for the dependent variable of mathematical academic achievement (F=.025, significance level=.976, for the Control Group; F=2.437, significance=.091, for the Experimental Group). Null Hypothesis 3a for the Control and Experimental Groups was retained.

Null Hypothesis 3b:

There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

The results in Tables 12 and 13 for the Control Group (F=.876, significance level=.460) and the Experimental Group (F=.611, significance level=.609) indicated no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical academic achievement. Null Hypothesis 3b for both Control and Experimental Groups was retained.

Tables 14-15 report the Table of Means for determining significant interaction and significant differences for main effects between the 3 socio-economic status groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude change. D is the mean of pre-post Aiken-Dreger Attitude Scale differences while () is the number of students in each category.

Table 14. Control Group. Table of Means. Hypotheses 4,4a,4b.

Socio-economic Status Group	Learning Style Treatment Groups I	II	III	IV
low D	-0.25 (4)	-4.00 (1)	-3.00 (1)	-3.00 (4)
medium D	0.00 (0)	0.00 (0)	1.00 (1)	2.50 (4)
high D	-0.25 (8)	1.25 (4)	-0.67 (15)	0.41 (17)

Table 15. Experimental Group. Table of Means. Hypotheses 4,4a,4b.

Socio-economic Status Group	Learning Style Treatment Groups I	II	III	IV
low D	2.14 (7)	1.50 (4)	-0.43 (14)	4.67 (9)
medium D	-0.50 (2)	-4.33 (3)	3.75 (4)	0.80 (10)
high D	0.52 (23)	1.69 (16)	1.11 (45)	1.21 (43)

Tables 16 and 17 report the Analysis of Variance results for determining significant interaction and significant differences for main effects between the 3 socio-economic status groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

Table 16. Control Group. ANOVA Results. Hypotheses 4,4a,4b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	13.985	3	4.662	0.209	0.890
columns (SES groups)	67.764	2	33.882	1.516	0.230
RxC	25.364	4	6.341	0.284	0.887
within	1095.451	49	22.356		
total	1197.627	58	20.649		

Table 17. Experimental Group. ANOVA Results. Hypotheses 4.4a.4b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	30.179	3	10.060	0.213	0.887
columns (SES groups)	24.967	2	12.484	0.265	0.768
RxC	242.916	6	40.486	0.859	0.526
within	7917.540	168	47.128		
total	8208.950	179	45.860		

Null Hypothesis 4:

There are no significant interactions between the 3 socio-economic status groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

The results in Tables 16 and 17 (Control and Experimental Groups) indicated no significant interactions between the 3 socio-economic status groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude change (F=.284, significance level=.887 for the Control Group; F=.859, significance level=.526 for the Experimental Group). Null Hypothesis 4 for the Experimental Group was retained.

Null Hypothesis 4a:

There are no significant differences between the 3 socio-economic status groups for the dependent variable of mathematical attitude change.

The results in Tables 16 and 17 indicated no significant differences between the 3 socio-economic status groups for the dependent variable of mathematical attitude change for the Control Group (F=1.516, significance level=.230) or for the Experimental Group (F=.265, significance level=.768). Null Hypothesis 4a was, therefore, retained for both Groups.

Null Hypothesis 4b:

There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

The results in Tables 16 and 17 indicated no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical attitude change. The Control Group (F=.209 at a significance level of .890) and the Experimental Group (F=.213 at a significance level of .887) required the Null Hypothesis 4b be retained for both Groups.

Two-way Analysis of Variance also involved the third general question:

3. Are pupils' attitudes toward mathematics affected as a result of matching teaching materials to preferred learner styles and teaching to those styles during a two-week unit on graphs and statistics?

Null Hypothesis 5 was presented to answer this question. The results are given in Tables 18-22.

Table 18 reports the means and standard deviations for pre- and post- MAT academic achievement tests used to determine the mathematical academic achievement groups of low, medium, and high.

Table 18. Control and Experimental Group. Mean and SD. Pre-post MAT.

	Difference Mean	Standard Deviation
Control Group	1.814	2.607
Experimental Group	1.644	2.641

Tables 19-20 give the Tables of Means for determining significant interaction and significant differences for main effects between the 3 mathematical academic achievement groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude change. D is the mean of pre-post Aiken-Dreger Attitude Scale differences while () is the number of students in each category.

Table 19. Control Group. Table of Means. Hypotheses 5.5a,5b.

Achievement Group	Learning Style Treatment Group I	II	III	IV
low D	0.00 (2)	3.00 (1)	1.00 (3)	0.33 (9)
medium D	-0.33 (6)	-0.50 (2)	-0.70 (10)	-2.00 (11)
high D	-0.25 (4)	-0.50 (2)	-2.00 (4)	4.80 (5)

Table 20. Experimental Group. Table of Means. Hypotheses 5.5a,5b.

Achievement Group	Learning Style Treatment Group I	II	III	IV
low D	2.33 (9)	1.40 (5)	0.89 (19)	1.88 (16)
medium D	0.87 (15)	2.78 (9)	2.13 (30)	1.04 (25)
high D	-1.00 (8)	-1.33 (9)	-0.57 (14)	2.57 (21)

Tables 21-22 report the Analysis of Variance results for determining significant interaction and significant differences for main effects between the 3 mathematical academic achievement groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

Table 21. Control Group. ANOVA Results. Hypotheses 5,5a,5b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	4.906	3	1.635	0.077	0.972
columns (ACHGRPS)	48.263	2	24.131	1.130	0.332
RxC	136.333	6	22.722	1.064	0.398
within	1003.983	47	21.361		
total	1197.627	58	20.649		

Table 22. Experimental Group. ANOVA Results. Hypotheses 5,5a,5b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	-419.919	3	139.973	3.829	0.012
columns (ACHGRPS)	-358.327	2	179.164	4.901	0.006
RxC	302.263	6	50.377	1.378	0.091
within	6141.026	168	36.554		
total	5665.043	179	31.648		

Null Hypothesis 5:

There are no significant interactions between the 3 mathematical academic achievement groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

The results of Tables 21 and 22 indicated no significant interaction for the Control Group (F=1.064, significance level=.398) or for Experimental Group (F=1.378, significance level=..091) between the 3 mathematical academic achievement groups and the 4 learning style treatment groups for the dependent variable of mathematical attitude change. Null Hypothesis 5 for the Control and the Experimental Groups was retained.

Null Hypothesis 5a:

There are no significant differences between the 3 mathematical academic achievement groups for the dependent variable of mathematical attitude.

The results in Tables 21 and 22 indicated no significant difference for the Control Group (F=1.130, significance level=.332). Significance at the .006 level (F=4.901) was found for the Experimental Group between the 3 mathematical academic achievement groups for the dependent variable of mathematical attitude change. Null Hypothesis 5a for the Control Group, therefore, was retained while Null Hypothesis for the Experimental was rejected.

Null Hypothesis 5b:

There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

The results in Tables 21 and 22 indicated no significant difference for the Control Group (F=.077, significance level=.972), while the Experimental Group indicated significance (F=3.829, significance level = .012) between the 4 learning style treatment groups for the dependent variable of mathematical attitude change. Null Hypothesis 5b for the Control Group was retained. Null Hypothesis 5b for the Experimental Group was rejected.

The fourth general question was also involved in the Two-way Analysis of Variance:

4. Are pupils' mathematical academic achievement scores affected as a result of matching teaching materials to preferred learner styles and teaching to those styles during a two-week unit on graphs and statistics?

Null Hypothesis 6 was presented to answer this question. The results are given in Tables 23-27.

Table 23 reports the means and standard deviations for the pre- and post- Aiken-Dreger Math Attitude Scale used to determine the mathematical attitude change groups of low, medium, and high.

Table 23. Control and Experimental Group. Mean and SD. Pre-Post Math Attitude Scale.

	Difference Mean	Standard Deviation
Control Group	-0.153	4.505
Experimental Group	1.150	6.753

Tables 24-25 report the Tables of Means for determining significant interaction and significant differences for main effects between the 3 mathematical attitude change groups and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement. D is the mean of pre-post MAT differences while () is the number of students in each category.

Table 24. Control Group. Table of Means. Hypotheses 6,6a,6b.

Attitude Change Groups	Learning Style Treatment Groups I	II	III	IV
low D	1.67 (3)	3.00 (2)	2.86 (7)	0.71 (7)
medium D	3.00 (7)	3.00 (1)	2.17 (6)	-0.09 (11)
high D	0.50 (2)	2.00 (2)	1.25 (4)	3.57 (7)

Table 25. Experimental Group. Table of Means. Hypotheses 6,6a,6b.

Attitude Change Groups	Learning Style Treatment Groups I	II	III	IV
low D	3.50 (4)	2.83 (6)	1.90 (20)	1.91 (11)
medium D	0.85 (20)	2.10 (10)	1.03 (29)	2.03 (39)
high D	2.38 (8)	1.43 (7)	1.14 (14)	1.17 (12)

Tables 26-27 give the Analysis of Variance results for determining significant interaction and significant differences for main effects between the 3 mathematical attitude change groups and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

Table 26. Control Group. ANOVA Results. Hypotheses 6,6a,6b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	19.118	3	6.373	0.986	0.407
columns (ATTGRPS)	7.704	2	3.852	0.596	0.555
RxC	70.506	6	11.751	1.819	0.116
within	303.659	47	6.461		
total	400.949	58	6.913		

Table 27. Experimental Group. ANOVA Results. Hypotheses 6,6a,6b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	16.347	3	5.449	0.770	0.512
columns (ATTGRPS)	19.398	2	9.699	1.371	0.257
RxC	33.787	6	5.631	0.796	0.574
within	1188.903	168	7.077		
total	1255.244	179	7.013		

Null Hypothesis 6:

There are no significant interactions between the 3 mathematical attitude change groups and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement..

The results in Tables 26 and 27 indicated no significant interaction for either the Control Group (F=1.819, significance level=.116) or the Experimental Group (F=.796, significance level=.574) between the 3 mathematical attitude change groups and the 4 learning style treatment groups for the dependent variable of mathematical academic achievement. Null Hypothesis 6 for both Control and Experimental Groups was retained.

Null Hypothesis 6a:

There are no significant differences between the 3 mathematical attitude change groups for the dependent variable of mathematical academic achievement.

The results in Tables 26 and 27 indicated no significant differences between the 3 mathematical attitude change groups for the dependent variable of mathematical academic achievement for either the Control Group (F=.596, significance level=.555) or the Experimental Group (F=1.371, significance level=.257). Null Hypothesis 6a for both Control and Experimental Groups was retained.

Null Hypothesis 6b:

There are no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical academic achievement.

The results in Tables 26 and 27 indicated no significant differences between the 4 learning style treatment groups for the dependent variable of mathematical academic achievement for either the Control Group (F=.986, significance level=.407) or the Experimental Group (F=.770, significance level=.512). Null Hypothesis 6b for both Control and Experimental Groups was retained.

Chi Square Test of Independence

This statistical analysis involved the fifth general question:

5. Are pupils' mathematical attitudes related to (dependent upon) matching teaching materials to preferred learner styles and teaching to those styles during a two-week unit on graphs and statistics?

Null Hypothesis 7 was presented to answer this question. The results of the Chi-Square Test of Independence are given in the form of percent frequency distributions.

Tables 28-29 report the Chi-square results for the nominal and ordinal data of the Aiken-Dreger Math Attitude Scale given to determine if mathematical attitude change groups are dependent on the learning style treatment groups.

Table 28. Control Group. Chi-square. Hypothesis 7.

	Learning Style Treatment Groups			
Mathematical Attitude Change Group	I	II	III	IV
Low	15.8% (3)	10.5% (2)	36.8% (7)	36.8% (7)
Medium	28.0% (7)	4.0% (1)	24.0% (6)	44.0% (11)
High	13.3% (2)	13.3% (2)	26.7% (4)	46.7% (7)
Chi-Square 3.24772	D.F. 6	Sign. 0.7772	Cells<5 6 of 12	

Table 29. Experimental Group. Chi-square. Hypothesis 7.

	Learning Style Treatment Groups			
Mathematical Attitude Change Group	I	II	III	IV
Low	9.8% (4)	14.6% (6)	48.8% (20)	26.8% (11)
Medium	20.4% (20)	10.2% (10)	29.6% (29)	39.8% (30)
High	19.5% (8)	17.1% (7)	34.1% (14)	29.3% (12)
Chi-Square 8.02146	D.F. 6	Sign. 0.2365	Cells<5 none	

Null Hypothesis 7:

The 3 mathematical attitude change groups are independent of the 4 learning style treatment groups.

The results in Tables 28 and 29 indicated no relationship between the 3 mathematical attitude change groups and the 4 learning style treatment groups. The Chi-Square values of 3.24772 (significance level=.7772) for the Control Group and 8.02146 (significance level=.2365) for the Experimental Group both indicated no statistical significance. Null Hypothesis 7, therefore, was retained for all Groups.

Null Hypothesis 8 was also presented to answer general question 5. The results of the Chi-Square Test of Independence are given in the form of percent frequency distributions.

Chi-square Contingency Table 30 gives the range of individual attitude test item response and learning style treatment group dependencies. This table is collapsed and relates each Likert-style response on the 20 statement Aiken-Dreger Math Attitude Scale to 1) Concrete (Sequential and Random) Learning Styles, and 2) Abstract (Sequential and Random) Learning Styles.

Table 30. Control and Experimental Group. Chi-square contingency tables (for each Math Attitude statement). Hypothesis 8.

	Control Group (DF = 4)			Experimental Group (DF = 4)		
#	X^2	Sign.	Cells<5	X^2	Sign.	Cells<5
1	4.63351	0.3270	6 of 10	1.65875	0.7982	4 of 10
2	7.94687	0.0935	6 of 10	8.07278	0.0889	4 of 10
3	0.53632	0.9699	6 of 10	7.08144	0.1316	1 of 10
4	3.85082	0.4266	6 of 10	7.94411	0.0936	none
5	1.40942	0.8426	6 of 10	4.61848	0.3287	2 of 10
6	4.50324	0.3422	6 of 10	4.31161	0.3655	2 of 10
7	1.07225	0.8987	6 of 10	2.38196	0.6659	2 of 10
8	2.30038	0.6807	6 of 10	6.77150	0.1485	2 of 10
9	2.72788	0.6043	6 of 10	7.42986	0.1148	2 of 10
10	1.65019	0.7997	6 of 10	1.43671	0.8378	2 of 10
11	4.24387	0.3740	6 of 10	4.60619	0.3655	none
12	4.34880	0.3609	6 of 10	2.07017	0.7229	2 of 10
13	6.15507	0.1879	6 of 10	2.78578	0.5943	2 of 10
14	1.62234	0.8048	6 of 10	6.33521	0.1755	none
15	0.60729	0.9623	6 of 10	3.54507	0.4711	none
16	3.47123	0.4823	6 of 10	1.94896	0.7451	4 of 10
17	4.55102	0.3365	6 of 10	1.84216	0.7648	3 of 10
18	3.96038	0.4114	6 of 10	0.36023	0.9856	none
19	4.43829	0.3499	6 of 10	8.49858	0.0749	none
20	1.73148	0.7850	6 of 10	3.36488	0.4987	none

Null Hypothesis 8:

The Mathematical Attitude Scale responses are independent of the 4 learning style treatment groups.

The results in Table 30 indicated no relationship between the 5 Math Attitude Scale responses and the 2 collapsed learning style treatment groups. The Chi-Square range of values for the 20 questions for the Control Group were from .53632 (significance level=.9699) to 7.94687 (significance level=.0935). The Chi Square range of values for the 20 questions for the Experimental Group were from .36023 (significance level=.9856) to 8.49858 (significance level=.0749). Null Hypothesis 8, therefore, was retained for both Control and Experimental Groups.

Scheffe' Analysis

This post-hoc statistical analysis was performed to locate the pairs of Mathematical Achievement Change Groups significantly different at the .05 level for Null Hypotheses 5a and 5b for the Investigative Study, Experimental Group . Significant difference was found for the main effect of Mathematical Academic Achievement Change Groups (ACHGRPS), and for the main effect of Learning Style Preference for the dependent variable of Mathematical Attitude.

Table 31. Experimental Group. Scheffe' Test. Null Hypotheses 5a,5b.

source	degrees of freedom	sum of squares	mean squares	F ratio	F prob.
between	6	302.263	50.377	1.378	.091
within	168	6141.026	36.554		
total	179	5665.043	31.648		

(*) denotes pairs of groups significantly different at the .05 level

ACHGRPS:

mean	group	H	M	L
0.50	H			
1.62	M			
1.53	L			

Learning Style Preference Groups:

mean	group	I	II	III	IV
0.73	I				
0.95	II				
0.82	III				
1.83	IV				

Table 31 reports the post hoc Scheffe' comparison test results for determining the location of significant differences among the 3 ACHGRPS, and among the 4 Learning Style preference groups when significant differences are found for the 3 ACHGRPS and for the 4 Learning Style treatment groups for the dependent variable Mathematical Attitude.

Table 31 indicated no significance at the .05 level. Neither the ACHGRPS nor the Learning Style Preference Groups have any pairs of groups significant at this level.

Discussion of Findings

Chapter 4 contains the tests of hypotheses for the Investigative Study. None of the hypotheses for the Control

Groups were found to be significant at the .05 level. Hypotheses 5a and 5b for the Experimental Group were found to be significant at the .05 level. Significant differences were found among the 3 ACHGRPS (Level = .006) and among the 4 Learning Style Groups (Level = .012). Post-hoc Scheffe' Analyses, however, located no pairs of groups for either difference significant at the .05 level. Mathematical Attitude mean difference scores for the Experimental High ACHGRPS were negative for all Learning Styles except for the Abstract Random Learning Style. Mathematical Attitude mean difference scores for the Experimental Low and Medium ACHGRPS were positive for all Learning Styles.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this investigation was to determine the statistical effects for matching learning materials with students' preferred learning styles upon mathematical academic achievement and attitudes when compared to a non-treatment group during a two-week unit on graphs and statistics. A study of any changes of mathematics achievement or change in attitude between the genders and among socio-economic status groups due to the experimental treatments was also included. The independent variables of the study were the 4 preferred learning styles, gender, 3 socio-economic status groups, 3 academic achievement groups, and 3 mathematical attitude change groups. The dependent variables were students' achievement difference on the Metropolitan Achievement Test (Post-test score - Pre-test score) and the students' mathematical attitude change on the Aiken-Dreger Mathematical Attitude Test (Post-test score - Pre-test score).

The general questions underlying the purpose of this investigation were:

1. Are the effects of matching teaching materials to preferred learner styles and teaching to those styles the same for males as for females during a two-week unit on graphs and statistics?

2. Are the effects of matching teaching materials to preferred learner styles and teaching to those styles the same for high, medium, and low socio-economic groups during a two week unit on graphs and statistics?
3. Are pupils' attitudes toward mathematics affected as a result of matching teaching materials to preferred learner styles and teaching to those styles during a two-week unit on graphs and statistics?
4. Are pupils' mathematical academic achievement scores affected as a result of matching teaching materials to preferred learner styles and teaching to those styles during a two-week unit on graphs and statistics?
5. Are pupils' mathematical attitudes related to (dependent upon) matching teaching materials to preferred learner styles and teaching to those styles during a two-week unit on graphs and statistics?

Subjects

The subjects for the Pilot Study included pupils from four seventh grade mathematics classes attending Bozeman Junior High School, Bozeman, MT, during the school year 1987-1988. One class was randomly chosen as the non-treatment Control Group (n=22) while the remaining 3 classes determined the Experimental Group (n=66).

The subjects for the Investigative Study included pupils from eleven seventh grade mathematics classes attending Bozeman Junior High School, Bozeman, MT, during the school year 1988-1989. One class for each of the three teachers was randomly chosen as the Control Group (n=59) while the remaining eight classes determined the Experimental Group (n=180).

Instrumentation

The subjects for both the Pilot and the Investigative Studies were administered the Gregorc Style Delineator. Four preferred learning styles were identified and labeled by the Delineator: Concrete Sequential (CS), Abstract Sequential (AS), Concrete Random (CR), and Abstract Random (AR). All subjects were classified according to their preferred learning style.

The Metropolitan Achievement Test, 5th Edition (1978), Mathematics Instructional Test (Graphs and Statistics) was administered in a pre-post basis to measure change in academic achievement. The test consisted of 24 items written in a multiple-choice format.

Attitude change was measured in a pre-post basis by the Aiken-Dreger Math Attitude Scale. The Scale consisted of 20 five-point Likert-type statements: 10 statements measuring positive attitude toward mathematics and 10 statements measuring negative attitude toward mathematics. The five points on each statement response scale were weighted with integers from one to five in the direction dislike-like and were then added. The total pre-score was subtracted from the total post-score to determine the attitude change difference score.

Duration

The Pilot Study was conducted during the third quarter of the school year 1987-1988. The Investigative Study was conducted during the 2nd quarter of the school year 1988-1989. For a period of two weeks the unit of graphs and statistics was taught to all subjects of the study. The learning style inventory was administered two months in advance. The pre and post tests for

both the Metropolitan Achievement Test and the Aiken-Dreger Math Attitude Scale were administered at the beginning and end of the two-week unit.

Research Design

Separate statistical two-way Analysis of Variance, Chi-Square Test of Independence and the post-hoc Schaffe' Analysis (where appropriate) were performed to test the null hypotheses. The hypotheses were tested at the .05 level of significance. All statistical analyses for both the Pilot and Investigative Studies were performed separately for the Control Groups and for the Experimental Groups using SPSS Version 9.1 on Montana State University's Honeywell Level 66 mainframe computer. Results of the Control and Experimental Groups were compared to further the interpretation of the findings.

Findings

The following findings are offered on the analyses of the data collected for this Investigative Study.

1) Null Hypothesis 5a for the Experimental Group was found to be significant at $p \leq 0.006$. Significant differences, therefore, exist between the 3 mathematical academic achievement groups for the dependent variable of mathematical attitude.

2) Null Hypothesis 5b for the Experimental Group was found to be significant at $p \leq 0.012$. Significant differences, therefore, exist between the 4 learning style treatment groups for the dependent variable of mathematical attitude change.

3) No significance was found for any of the Null Hypotheses for the Control Group. No significance was found for Null Hypotheses 1, 1a, 1b, 2, 2a, 2b, 3, 3a, 3b, 4, 4a, 4b, 5, 6, 6a, 6b, 7, or 8 for the Experimental Group.

Conclusions

The following conclusions are offered on the analyses of the data collected from this study:

1) Students who earned a Low mathematical achievement pre-post difference score improved their mathematical attitude for all Learning Styles by the use of matching teaching materials to their learning styles in the classroom.

2) Students who earned a Medium mathematical achievement pre-post difference score improved their mathematical attitude for all Learning Styles by the use of matching teaching materials to their learning styles in the classroom.

3) Students who earned a High mathematical achievement pre-post difference score improved their mathematical attitude for the Abstract Random Learning Style by the use of matching teaching materials to their learning styles in the classroom.

Discussion of the Research

Statistical analyses revealed significance for the Experimental Group for Null Hypotheses 5a, and 5b. These results supported the mathematical attitude research by Aiken (1961, 1964, 1972), Dutton (1956, 1962), and Cox & Capps (1969). These results also supported the mathematical attitude, achievement and learning style research of Belcastro (1966), Jones (1968), Dunn (1978), Roach (1979), Onyeuiaku (1982), Ben-Haim (1982), Cramond (1982), Virostko (1983), Spires (1983), Corbo (1984), Costello (1984), Calvano (1985), Hodges (1985), Blitch (1985), Berman (1985), Hadfield (1986).

All other Null Hypotheses of this study were found to have no significance at the .05 level. Positive relationships for this study, however, were found to support the research concerned

with learning theory, achievement, and attitude. Research which revealed no significance, but indicated positive relationships between attitude and/or achievement, and learning styles include Verbeke (1982), Samuels (1983), Mason (1985), Smith (1986), Jones (1968), Evertson (1981), and Olsen (1983).

Further inspection of the Tables of Means for this study revealed the following levels of significance, positive relationships, and implications:

Null Hypotheses 1($p \leq .280$), 1a($p \leq .399$), 1b($p \leq .562$): Tables 2 and 3 showed the greatest mathematical academic achievement improvement for Males (Experimental Group as compared to Control Group) for Learning Style Treatment Group IV (Abstract Random) as +1.78. The greatest mathematical academic achievement improvement for Females was also for Learning Style Treatment Group IV (+.15). This result disagrees with the results of the Pilot Study in which Female achievement was greater than Male achievement for the AR Learning Style Treatment Group. It can be noted that Male-Female differences for the Experimental Group (Investigative Study) indicate Female achievement was greater (+1.60) than Male achievement for the Abstract Sequential (AS) Learning Style Treatment Group. Female achievement decreased the most for the Concrete Sequential (CS) Learning Style Group.

Hypotheses 2 ($p \leq .990$), 2a ($p \leq .114$), 2b ($p \leq .888$): Tables 6 and 7 indicated the greatest mathematical attitude improvement for Males (+2.50) was for the Learning Style Treatment Group IV (Abstract Random) while the greatest mathematical attitude improvement for Females (+1.26) was for the Learning Style Treatment Group III (Concrete Random). Mathematical attitude improved for Males for all Learning Style Treatment Groups while improving for Females for three of the Learning Style Treatment Groups (Abstract Sequential, Concrete Random, Abstract Random).

The difference in significance for the main effect of Gender for the Control Group (.991) and the Experimental Group (.114) indicated a diversity between the Groups.

Hypotheses 3 ($p \leq .619$), 3a ($p \leq .091$), 3b ($p \leq .609$): Tables 10 and 11 revealed increases for Mathematical Academic Achievement in the Abstract Random Learning Style Treatment Group for all Socio-economic Status Groups. The Low SES group improved +4.03, Medium SES improved +.10, and the High SES group improved +.08. Medium SES group also increased in achievement +2.00 for the Concrete Random Learning Style Group.

The difference in significance levels for the Control Group (.976) and the Experimental Group (.091) indicated a variance significant at the .10 level.

Hypotheses 4 ($p \leq .526$), 4a ($p \leq .768$), 4b ($p \leq .887$): Tables 14 and 15 revealed the greatest improvement for Mathematical Attitude for the Low SES Group to be the Abstract Random Learning Style Group (+7.67), for the Medium SES Group the Concrete Random Learning Style Group (+2.75), and for the High SES Group the Concrete Random Learning Style Group (+1.78). Mathematical Attitudes improved for all Learning Style Groups for each of the Low and High SES Groups. The Medium SES Group Attitudes improved for the Concrete Random Learning Style Group, dropped for the Abstract Random Learning Style Group, and could not be determined for the Concrete Sequential and Abstract Sequential Learning Style Groups due to $n=0$ for these groups.

The significant interaction between the 3 Mathematical Academic Achievement Groups and the 4 Learning Style Treatment Groups of the Pilot Study (significance level = .036) were found to be refuted at the .05 level by the results of the Investigative Study (significance level = .091).

Hypothesis 5 ($p \leq .091$): Tables 19 and 20 revealed that the High Achievement Group mean score differences were less than

the Medium and Low Achievement Group mean score differences for all learning style groups except for the Abstract Random Learning Style.

Hypotheses 6 ($p \leq .574$), 6a ($p \leq .257$), 6b ($p \leq .512$): The interaction significance level for the Control Group of .116 and the Experimental Group significance level of .574 suggests a variance between the groups, particularly for the High Attitude change groups with Abstract Random Learning Styles. For all Learning Style groups, except Abstract Random, the High Attitude change group mean difference scores were less than the Low and Medium Attitude change group scores.

Tables 24 and 25 indicate the greatest increase in Mathematical Academic Achievement for 1) the Low Attitude Change Group is the Concrete Sequential Learning Style Group (+1.83), 2) the High Attitude Change Group is also the Concrete Sequential Learning Style Group (+1.88), and 3) the Medium Attitude Change Group is the Abstract Random Learning Style Group (+2.12). According to the tables, the greatest decrease in Mathematical Academic Achievement for 1) the Low Attitude Change Group is the Concrete Random Learning Style Group (-.96), 2) the High Attitude Change Group is the Abstract Random Learning Style Group (-2.40), and 3) the Medium Attitude Change Group is the Concrete Sequential Learning Style Group (-2.15).

Hypothesis 8: Table 30 indicated Attitude Scale response #2 significant at the .0935 level for the Control Group and .0889 for the Experimental Group. This statement, "I do not like mathematics, and it scares me to have to take it.", was answered "Strongly Disagree" by 58.6% of the Pilot Study Concrete Learning Style Groups and 23.3% of the Pilot Study Abstract Learning Style Groups (Appendix B, Table 32). 31.0% of the Pilot Study Concrete Learning Style Groups and 56.7% of the Pilot Study Abstract Learning Style Groups answered this statement "Disagree". The Investigative Study results indicate 43.2% of the Concrete Learning Style Groups and 47.1% of the Abstract Learning Style

Groups answered "Strongly Disagree" to this statement. 33.7% of the Concrete Learning Style Groups and 43.5% of the Abstract Learning Style Groups answered "Disagree". Experimental treatment decreased the Strongly Disagree response (15.4%) for the Concrete Learning Style Groups and increased the Disagree response (2.7%). Abstract Learning Style Groups increased 23.8% for the Strongly Disagree response and decreased 13.2% for the Disagree response.

Attitude Scale response #4 had a significance level of .0936 for the Experimental Group. This statement, "Mathematics is fascinating and fun.", was answered "Agree" by 28.4% of the Experimental Concrete Learning Style Groups and 45.9% of the Experimental Abstract Learning Style Groups. This same statement was answered "Agree" by 34.5% of the Control Concrete Learning Style Groups and 33.3% of the Control Abstract Learning Style Groups. Experimental treatment, it appears, decreases the "Agree" response for this statement for the Concrete Learning Style Groups (-6.1%) and increases the "Agree" response for the Abstract Learning Style Groups (+12.6%). The "Undecided" response decreased 13.0% for the Concrete Learning Style Groups and decreased 12.9% for the Abstract Learning Style Groups (Table 33).

Attitude Scale response #19 had a significance level of .0749 for the Experimental Group. This statement, "I feel at ease in mathematics, and I like it very much.", was answered "Agree" by 36.8% of the Experimental Concrete Learning Style Groups and 55.3% of the Experimental Abstract Learning Style Groups. This statement was answered "Agree" by 44.8% of the Control Concrete Learning Style Groups and 43.4% of the Control Abstract Learning Style Groups. Experimental treatment, for this statement, decreases the "Agree" response (-8.0%) for the Concrete Learning Style Groups and increases the "Agree" response (+12.0%) for the Abstract Learning Style Groups (Table 34).

Recommendations

Recommendations for Education.

The following recommendations are offered on the analyses of the data collected for the Investigative Study.

Teachers should be encouraged to group:

1) All Learning Style Low Mathematical Achievement Groups,

2) All Learning Style Medium Mathematical Achievement Groups, and

3) Abstract Random High Mathematical Achievement Groups and that these groups be matched to their Learning Style teaching materials in the classroom in order to increase Mathematical Attitude.

Recommendations for Research.

The following recommendations are offered on the analyses of the data collected for the Investigative Study.

1) Further study should be conducted to further define the effects of grouping Gender and student preferred learning styles and matching teaching materials to these learning styles in order to increase Mathematical Academic Achievement.

2) Further study should be conducted to further define the effects of grouping Gender and student preferred learning styles and matching teaching materials to these learning styles in order to increase Mathematical Attitude.

3) Further study should be conducted to further define the effects of grouping Socio-economic Status groups and student preferred learning styles and matching teaching materials to these learning styles in order to increase Mathematical Academic Achievement.

4) Further study should be conducted to further define the effects of grouping Socio-economic Status groups and student preferred learning styles and matching teaching materials to these learning styles in order to increase Mathematical Attitude.

5) This Study should be replicated with a larger sample. The larger sample study may further corroborate the results of this Study.

6) Further Study should be replicated at different grade levels, subjects areas, and within other demographical areas of the country. The single grade level, single mathematical unit of graphs and statistics, and the rural population of the study limit the possible generalizations.

7) One of the limitations of this study was the teachers' abilities to manage the four treatment groups simultaneously in a classroom. Future research needs to be conducted with students grouped according to their preferred learning styles and placed in one classroom such that a teacher will be responsible for managing only the one treatment group in the classroom.

8) Further research should be conducted to determine longitudinal effects of matching teaching materials to students' preferred learning styles. Retesting Control and Experimental Group students for long-term retention of achievement and attitude change should be studied. The effects of year-long matching of teaching materials to students' preferred learning styles also needs to be studied.

9) Further research should be conducted to develop a Gregorc Style Delineator with vocabulary appropriate for the twelve to fifteen years of age student. Students and teachers involved in these studies expressed frustration with the vocabulary used in the current Gregorc Style Delineator. Further research should then be conducted to substantiate the use of the results of the newly developed Delineator with the learning style teaching materials and methods used for this study.

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APPENDICES

APPENDIX A

AIKEN DREGER MATH ATTITUDE SCALE

Aiken Dreger Math Attitude Scale

Each of the statements on this opinionnaire expresses a feeling which a particular person has toward mathematics. You are to express, on a five point scale, the extent of agreement between the feeling expressed in each statement and your own personal feeling. Fill in the dot on the answer sheet for the letter which best indicates how closely you agree or disagree with the feeling expressed in each statement AS IT CONCERNS YOU. (Directions adapted for this study.)

The five points are:
Strongly Disagree (SD), Disagree (D), Undecided (U), Agree (A), Strongly Agree (SA). Fill in the dots on the answer sheet using the A B C D E as indicated for each column.

		A B C D E
1.	I am always under a terrible strain in math class.	SD D U A SA
2.	I do not like mathematics, and it scares me to have to take it.	SD D U A SA
3.	Mathematics is very interesting to me, and I enjoy math courses.	SD D U A SA
4.	Mathematics is fascinating and fun.	SD D U A SA
5.	Mathematics makes me feel secure, and at the same time it is stimulating.	SD D U A SA
6.	My mind goes blank, and I am unable to think clearly when working math.	SD D U A SA
7.	I feel a sense of insecurity when attempting mathematics.	SD D U A SA

8.	Mathematics makes me feel uncomfortable, restless, irritable, and impatient.	SD D U A SA
9.	The feeling that I have toward mathematics is a good feeling.	SD D U A SA
10.	Mathematics makes me feel as though I'm lost in a jungle of numbers and can't find my way out.	SD D U A SA
11.	Mathematics is something which I enjoy a great deal.	SD D U A SA
12.	When I hear the word math, I have a feeling of dislike.	SD D U A SA
13.	I approach math with a feeling of hesitation, resulting from a fear of not being able to do math.	SD D U A SA
14.	I really like mathematics.	SD D U A SA
15.	Mathematics is a course in school which I have always enjoyed studying.	SD D U A SA
16.	It makes me nervous to even think about having to do a math problem.	SD D U A SA
17.	I have never liked math, and it is my most dreaded subject.	SD D U A SA
18.	I am happier in a math class than in any other class.	SD D U A SA
19.	I feel at ease in mathematics, and I like it very much.	SD D U A SA
20.	I feel a definite positive reaction to mathematics; it's enjoyable.	SD D U A SA

APPENDIX B

INVESTIGATIVE STUDY. CHI-SQUARE CONTINGENCY TABLES.

INVESTIGATIVE STUDY. CHI-SQUARE CONTINGENCY TABLES.

Table 32. Attitude Scale Statement 2.

	Statement Response (in %)				
	SD	D	U	A	SA
Control Concrete	58.6	31.0	3.4	3.4	3.4
Control Abstract	23.3	56.7	6.7	10.0	3.3
Experimental Concrete	43.2	33.7	14.7	5.3	3.2
Experimental Abstract	47.1	43.5	3.5	4.7	1.2

Table 33. Attitude Scale Statement 4.

	Statement Response (in %)				
	SD	D	U	A	SA
Control Concrete	3.4	10.3	41.4	34.5	10.3
Control Abstract	16.7	3.3	40.0	33.3	6.7
Experimental Concrete	8.4	16.8	28.4	28.4	17.9
Experimental Abstract	8.2	9.4	27.1	45.9	9.4

Table 34. Attitude Scale Statement 19.

	Statement Response (in %)				
	SD	D	U	A	SA
Control Concrete	6.9	6.9	27.6	44.8	13.8
Control Abstract	10.0	23.3	13.3	43.3	10.0
Experimental Concrete	8.4	15.8	23.2	36.8	15.8
Experimental Abstract	7.1	16.5	10.6	55.3	10.6

APPENDIX C

PILOT STUDY STATISTICAL ANALYSES TABLES

PILOT STUDY STATISTICAL ANALYSES TABLES

Table 35. Number of Students in Each Group.

Number Students	PILOT STUDY Experimental	Control
total	66	22
males	33	10
females	33	11
Low SES	9	1
Middle SES	3	1
High SES	54	20
Low ATTGRPS	17	7
Middle ATTGRPS	30	8
High ATTGRPS	19	7
Low ACHGRPS	25	10
Middle ACHGRPS	25	7
High ACHGRPS	16	5
Learning Style I	15	8
Learning Style II	3	1
Learning Style III	24	6
Learning Style IV	24	7

Table 36. Control Group. Table of Means. Hypotheses 1,1a,1b.

	Learning Style Treatment Groups			
Gender	I	II	III	IV
male D	4.33 (6)	0.00 (0)	1.50 (2)	2.50 (2)
female D	0.00 (2)	1.00 (1)	2.50 (4)	1.50 (4)

Table 37. Experimental Group. Table of Means. Hypotheses 1,1a,1b.

	Learning Style Treatment Groups			
Gender	I	II	III	IV
male D	2.75 (8)	3.00 (1)	4.44 (18)	-0.17 (6)
female D	1.57 (7)	0.50 (2)	0.17 (6)	2.56 (18)

Table 38. Control Group. ANOVA Results.Hypotheses 1.1a,1b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	2.001	3	0.667	0.075	0.972
columns (gender)	11.207	1	11.207	1.264	0.280
RxC	19.043	2	9.522	1.074	0.368
within	124.083	14	8.863		
total	164.952	20	8.248		

Table 39. Experimental Group. ANOVA Results. Hypotheses 1.1a,1b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	15.183	3	5.061	0.309	0.819
columns (gender)	12.742	1	12.742	0.778	0.381
RxC	112.305	3	37.435	2.285	0.088
within	950.270	58	16.384		
total	1108.439	65	17.053		

Table 40. Control Group. Table of Means. Hypotheses 2.2a.2b.

	Learning Style Treatment Groups			
Gender	I	II	III	IV
male D	-8.33 (6)	0.00 (0)	-2.00 (2)	-2.50 (2)
female D	8.50 (2)	5.00 (1)	1.25 (4)	-7.25 (4)

Table 41. Experimental Group. Table of Means. Hypotheses 2.2a.2b.

	Learning Style Treatment Groups			
Gender	I	II	III	IV
male D	-1.88 (8)	-6.00 (1)	-3.00 (18)	-4.83 (6)
female D	2.29 (7)	8.00 (2)	0.33 (6)	-1.72 (18)

Table 42. Control Group. ANOVA Results. Hypotheses 2,2a,2b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	135.230	3	45.077	0.252	0.858
columns (gender)	129.735	1	129.735	0.727	0.408
RxC	339.473	2	169.737	0.951	0.410
within	2499.833	14	178.560		
total	3145.810	20	157.290		

Table 43. Experimental Group. ANOVA Results. Hypotheses 2,2a,2b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	184.575	3	61.525	0.689	0.563
columns (gender)	216.539	1	216.539	2.424	0.125
RxC	72.313	3	24.104	0.270	0.847
within	5182.081	58	89.346		
total	5612.439	65	86.345		

Table 44. Control Group. Table of Means. Hypotheses 3,3a,3b.

Socio-economic Status Group	Learning Style Treatment Group I	II	III	IV
low D	13.00 (1)	0.00 (0)	0.00 (0)	0.00 (0)
medium D	0.00 (0)	0.00 (0)	0.00 (0)	3.00 (1)
high D	1.86 (7)	1.00 (1)	2.00 (6)	1.83 (6)

Table 45. Experimental Group. Table of Means. Hypotheses 3,3a,3b.

Socio-economic Status Group	Learning Style Treatment Group I	II	III	IV
low D	-0.50 (2)	0.00 (0)	4.00 (4)	4.67 (3)
medium D	0.00 (0)	0.50 (2)	4.00 (1)	0.00 (0)
high D	2.62 (13)	3.00 (1)	3.21 (19)	1.48 (21)

Table 46. Control Group. ANOVA Results. Hypotheses 3.3a,3b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	0.860	3	0.287	0.100	0.959
columns (SES groups)	109.810	2	54.905	19.227	0.000
RxC	Information suppressed (empty cells/singular matrix)				
within	45.690	16	2.856		
total	165.318	21	7.872		

Table 47. Experimental Group. ANOVA Results.Hypotheses 3.3a,3b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	30.162	3	10.054	0.559	0.644
columns (SES groups)	4.423	2	2.211	0.123	0.885
RxC	45.754	3	15.251	0.848	0.473
within	1025.140	57	17.985		
total	1108.439	65	17.053		

Table 48. Control Group. Table of Means. Hypotheses 4,4a,4.

Socio-economic Status Group	Learning Style Treatment Groups I	II	III	IV
low D	4.00 (1)	0.00 (0)	0.00 (0)	0.00 (0)
medium D	0.00 (0)	0.00 (0)	0.00 (0)	-3.00 (1)
high D	-5.29 (7)	5.00 (1)	0.17 (6)	-5.67 (6)

Table 49. Experimental Group. Table of Means. Hypotheses 4,4a,4b.

Socio-economic Status Group	Learning Style Treatment Groups I	II	III	IV
low D	-1.00 (2)	0.00 (0)	6.00 (4)	-4.67 (3)
medium D	0.00 (0)	8.00 (2)	2.00 (1)	0.00 (0)
high D	0.23 (13)	-6.00 (1)	-4.11 (19)	-2.19 (21)

Table 50. Control Group. ANOVA Results. Hypotheses 4,4a,4b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	202.155	3	67.385	0.373	0.774
columns (SES groups)	81.542	2	40.771	0.225	0.801
RxC	Information suppressed (empty cells/singular matrix)				
within	2893.595	16	180.850		
total	33145.818	21	149.801		

Table 51. Experimental Group. ANOVA Results. Hypotheses 4,4a,4b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	78.608	3	26.203	0.301	0.825
columns (SES groups)	196.337	2	98.169	1.127	0.331
RxC	308.594	3	102.865	1.181	0.325
within	4966.002	57	87.123		
total	5612.439	65	86.345		

Table 52. Control and Experimental Group. Mean and SD. Pre-Post MAT.

	Difference Mean	Standard Deviation
Control Group	2.409	2.7410
Experimental Group	2.470	4.098

Table 53. Control Group. Table of Means. Hypotheses 5.5a,5b.

Achievement Group	Learning Style Treatment Group I	II	III	IV
low D	-1.67 (3)	5.00 (1)	-4.00 (3)	-2.67 (3)
medium D	-7.50 (2)	0.00 (0)	6.50 (2)	-2.67 (3)
high D	-4.33 (3)	0.00 (0)	0.00 (1)	-21.00 (1)

Table 54. Experimental Group. Table of Means. Hypotheses 5.5a,5b.

Achievement Group	Learning Style Treatment Group I	II	III	IV
low D	2.50 (6)	-3.00 (1)	2.64 (11)	-5.14 (7)
medium D	-3.17 (6)	6.50 (2)	-3.67 (3)	-3.71 (14)
high D	1.67 (3)	0.00 (0)	-7.00 (10)	9.33 (3)

Table 55. Control Group. ANOVA Results. Hypotheses 5.5a,5b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	159.538	3	53.179	0.254	0.857
columns (ACHGRPS)	88.161	2	44.080	0.210	0.813
RxC	373.309	4	93.327	0.446	0.774
within	2513.667	12	209.472		
total	3145.818	21	149.801		

Table 56. Experimental Group. ANOVA Results. Hypotheses 5.5a,5b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	152.870	3	50.957	0.649	0.587
columns (ACHGRPS)	133.806	2	66.903	0.852	0.432
RxC	1016.035	5	203.207	2.586	0.036
within	4321.093	55	78.565		
total	5612.439	65	86.345		

Table 57. Control and Experimental Group. Mean and SD. Pre-Post Math Attitude Scale.

	Difference Mean	Standard Deviation
Control Group	-2.909	11.958
Experimental Group	-1.530	9.222

Table 58. Control Group. Table of Means. Hypotheses 6,6a,6b.

Attitude Change Group	Learning Style Treatment Groups I	II	III	IV
low D	2.00 (4)	0.00 (0)	0.00 (0)	2.67 (3)
medium D	2.00 (1)	0.00 (0)	1.80 (5)	2.00 (2)
high D	5.33 (3)	1.00 (1)	3.00 (1)	1.00 (2)

Table 59. Experimental Group. Table of Means. Hypotheses 6,6a,6b.

Attitude Change Group	Learning Style Treatment Groups I	II	III	IV
low D	2.00 (1)	0.00 (0)	4.86 (5)	1.00 (2)
medium D	2.38 (8)	1.00 (1)	3.50 (7)	1.10 (6)
high D	2.00 (5)	2.00 (1)	1.71 (7)	4.33 (6)

Table 60. Control Group. ANOVA Results. Hypotheses 6,6a,6b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	10.323	3	3.441	0.344	0.794
columns (ATTGRPS)	6.663	2	3.331	0.333	0.723
RxC	18.704	3	6.235	0.623	0.613
within	130.133	13	10.010		
total	165.318	21	7.872		

Table 61. Experimental Group. ANOVA Results. Hypotheses 6,6a,6b.

variation	sum of squares	DF	mean square	F	sig of F
rows (styles)	32.084	3	10.695	0.594	0.622
columns (ATTGRPS)	2.084	2	1.042	0.058	0.944
RxC	82.339	5	16.468	0.914	0.479
within	990.894	55	18.016		
total	1108.439	65	17.053		

Table 62. Control Group. Chi-square. Hypothesis 7.

	Learning Style Treatment Groups			
Mathematical Attitude Change Group	I	II	III	IV
Low	57.1% (4)	-- (0)	-- (0)	42.9% (3)
Medium	12.5% (1)	-- (0)	62.5% (5)	25.0% (2)
High	42.9% (3)	14.3% (1)	14.3% (1)	28.6% (2)
Chi-Square	D.F.	Sign.	Cells<5	
10.69834	6	0.0982	12 of 12	

Table 63. Experimental Group. Chi-square. Hypothesis 7.

	Learning Style Treatment Groups			
Mathematical Attitude Change Group	I	II	III	IV
Low	11.8% (2)	-- (0)	41.2% (7)	47.1% (8)
Medium	26.7% (1)	6.7% (0)	33.3% (10)	33.3% (10)
High	26.3% (5)	5.3% (1)	36.8% (7)	31.6% (6)
Chi-Square	D.F.	Sign.	Cells<5	
3.21804	6	0.7810	5 of 12	

Table 64. Control and Experimental Group. Chi-square contingency tables (for each Math Attitude question). Hypothesis 8.

	Control Group				Experimental Group			
#	X^2	DF	Sign.	Cells<5	X^2	DF	Sign.	Cells<5
1	4.82232	3	.1853	6 of 8	3.06053	4	.5477	6 of 10
2	1.77160	2	.4124	4 of 6	3.07958	3	.3795	4 of 8
3	0.93304	4	.9198	9 of 10	1.80374	4	.7718	5 of 10
4	1.62755	3	.6532	8 of 8	4.91459	4	.2962	6 of 10
5	3.64422	4	.4563	10 of 10	6.04467	4	.1958	4 of 10
6	0.78068	3	.8541	7 of 8	1.60435	4	.8080	5 of 10
7	0.01637	2	.9918	4 of 6	1.59645	4	.2235	4 of 10
8	0.54014	3	.9100	8 of 8	4.37224	4	.3580	5 of 10
9	6.05187	4	.1953	10 of 10	5.69072	4	.2235	4 of 10
10	0.47517	3	.9243	7 of 8	1.45833	4	.8340	6 of 10
11	1.68929	3	.6393	7 of 8	6.44062	4	.1686	4 of 10
12	5.81429	4	.2135	9 of 10	2.96235	4	.5641	5 of 10
13	0.96905	3	.8087	7 of 8	6.47803	4	.1662	5 of 10
14	1.37718	3	.7109	7 of 8	3.72673	4	.4442	4 of 10
15	0.32083	3	.9561	7 of 8	2.58631	4	.6292	4 of 10
16	5.14643	4	.2726	9 of 10	0.11313	4	.9985	6 of 10
17	4.49821	4	.3428	9 of 10	0.85021	3	.8374	2 of 8
18	0.70153	3	.8728	8 of 8	0.20292	4	.9952	4 of 10
19	1.30344	3	.7283	7 of 8	2.13902	4	.7102	5 of 10
20	1.76786	4	.7784	9 of 10	1.11925	4	.8912	5 of 10

Table 65. Control Group. Scheffe' Test. Null Hypothesis 3a.

source	degrees of freedom	sum of squares	mean squares	F ratio	F prob.
between	2	118.7682	59.3841	24.2384	0.0000
within	19	46.5500	2.4500		
total	21	165.3182			

(*) denotes pairs of groups significantly different at the .05 level

mean	group	H	M	L
1.85	H			
3.00	M			
13.00	L	*	*	

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